

CHAPTER 4

TECHNICAL DRAWINGS

Overview

Introduction

In the United States, modern technical drawing can be traced to the year 1849 when a Baltimore, Maryland, schoolteacher published what is widely believed to be the first text on technical drawing. At that time, technical drawings were fine line drawings that resembled copperplate engravings. With the introduction of the blueprint process in 1876, fine line drawings became obsolete and modern technical drawings evolved. The Industrial Revolution in the early 1900s further refined, defined, and standardized technical drawing techniques, nomenclature, and symbology. The term *technical drawing* accurately suggests the broad scope of drawings for industry.

Objectives

The material in this chapter enables you to do the following:

- Identify the application of freehand drawing techniques in technical drawings.
 - Describe freehand technical sketching techniques.
 - Differentiate between technical sketching and technical drawings.
 - Understand the importance of proportion and accuracy in technical drawing.
 - Recognize graphic symbols for electrical and mechanical drawings.
 - Recognize graphic symbols for structural drawings.
 - Identify machine drawing screw thread technology.
 - Interpret piping blueprints.
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Overview, Continued

Acronyms

The following table contains a list of acronyms you must know to understand the material in this chapter:

Acronym	Meaning
A	Addendum
AC	Addendum Circle
ANSI	American National Standards Institute
ASCE	American Society of Construction Engineers
ASME	American Society of Mechanical Engineers
C	Clearance
CAD	Computer Aided Drafting
CAM	Computer Aided Manufacturing
CP	Circular Pitch
D	Dedendum
DIA	Diameter
DP	Diametral Pitch
DOD-STD	Department of Defense Standards
MIL-STD	Military Standards
N	Number of teeth
NC	National Course
NF	National Fine
OC	On Center
OD	Outside Diameter
PD	Pitch Diameter

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Overview, Continued

Acronyms (Continued)

Acronym	Meaning
PLS	Places
R	Radius
RD	Root Diameter
SECT	Section
TYP	Typical
UNC	Unified National Course
WD	Whole Depth

In this chapter This chapter covers the following topics:

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Technical Drawings and Sketches

Introduction

The entire world depends upon technical drawings to convey the ideas that feed today's industrialized society. Architectural, structural, electric, electronic, machine, plumbing, and piping drawings are all forms of mechanical/technical drawings. When rendering technical drawings, accuracy, neatness, technique, and speed in execution are essential. Inaccurate drawings could be worthless or lead to costly errors.

Technical drawings and sketches

Technical drawing is a necessarily broad term that applies to any drawing used to express technical ideas. Technical drawings are usually mechanically refined by using straightedges, triangles, and drafting instruments. Many of these drawings begin as a form of sketching. *Technical sketching* is a freehand sketch. The only equipment required to execute technical sketches are soft pencils in the F to HB range, paper, and an eraser. The novice sketcher may find paper that is cross sectioned with ruled lines beneficial in establishing and maintaining scale. There are gridded papers, isometric papers for isometric sketches, and perspective papers for sketches requiring perspective available. When selecting an eraser, chose a soft (pink) or artgum eraser.

Types of sketches

Since technical sketches and drawings represent three-dimensional objects, your sketches should conform to one of the four standard types of projection. The four major types of projection are (1) multiview, (2) axonometric, (3) oblique, and (4) perspective. Each type of projection is covered in detail in later chapters of this volume.

Figure 4-1 shows the four types of projections.

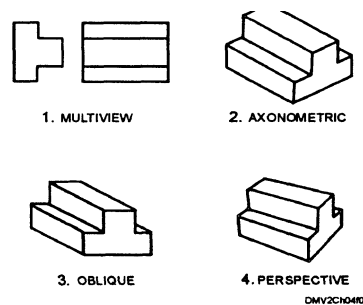


Figure 4-1.—The four types of projections.

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Technical Drawings and Sketches, Continued

Scale

Technical sketches are not made to any scale. The size of your sketch depends upon the complexity of the object and the size of your paper. They are preludes to fabrication drawings (requiring precise measurements) and only meant to convey an overall idea. Using gridded or ruled sketching paper helps you to draw objects to size.

Figure 4-2 shows various types of ruled papers.

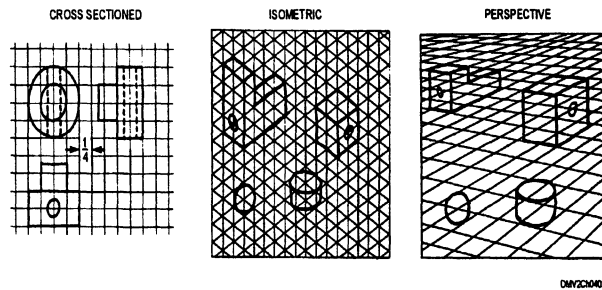


Figure 4-2.—Ruled sketch paper.

Proportion

Technical sketches must be proportional. No matter how much attention you pay to detail or how good your technique is, if the proportions are incorrect, the image is not successful. One method of establishing proportion is to use a small dowel or your pencil as a measuring stick representing an arbitrary unit of measure. Begin establishing proportion by comparing height-to-width ratios. Visually transpose that measurement to your paper. As you proceed with the sketch, continue to compare larger areas with smaller areas using the dowel or pencil as a ruler.

Figure 4-3 illustrates how to use a dowel or pencil as a unit of measure.

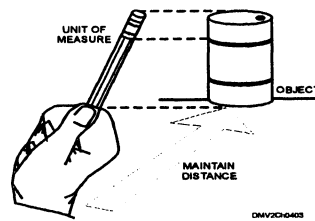


Figure 4-3.—Using a pencil as a unit of measure.

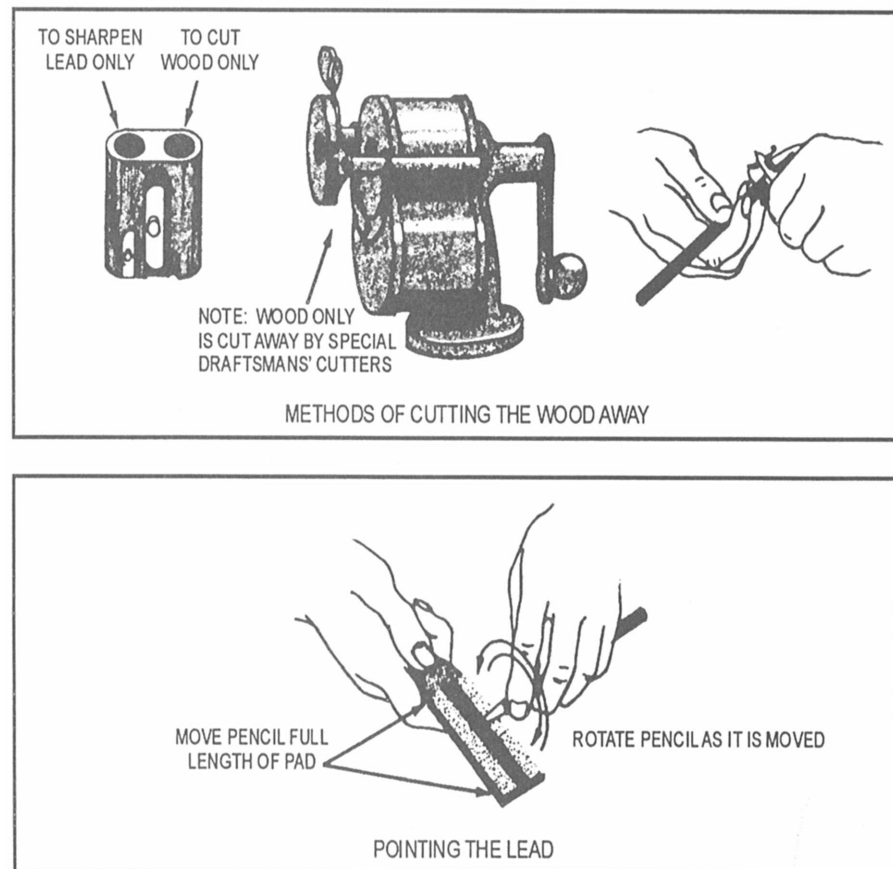
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Technical Drawing and Sketching, Continued

Sharpening your sketch pencils

To maintain uniform pencil width and pinpoint accuracy, you should sharpen your pencil lead to a conical point. Standard office pencil sharpeners are fine for keeping the lead pointed. Also available are sharpeners that remove only the wooden encasement surrounding the graphite lead. These sharpeners require you to shape the lead by dragging the lead across a sandpaper pad while rotating the pencil simultaneously between your thumb and forefinger. For detailed instructions on sharpening pencil leads, see *DM, Volume I*, chapter 1.

Figure 4-4 shows how to point the pencil lead.



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Figure 4-4.—Sharpening a pencil.

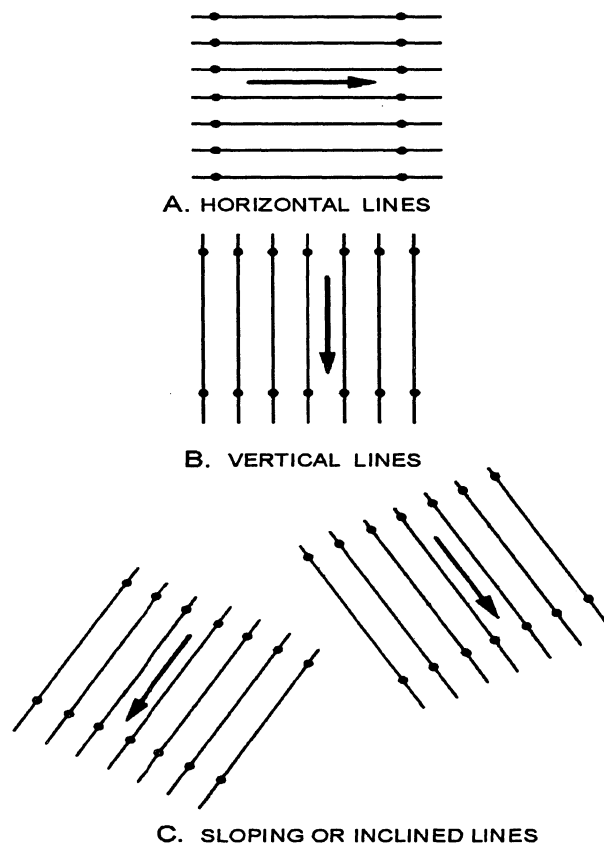
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Technical Drawing and Sketching, Continued

Drawing straight lines

Pencil strokes are made by combined movements of your wrist and fingers. Sketch vertical and diagonal lines that slope to the left from top to bottom. Horizontal and diagonal lines that slope to the right are drawn from left to right. To help you become more proficient at sketching straight lines, place a series of dots approximately 1 inch apart and connect the dots with a series of short strokes. The better you become at sketching straight lines, the farther apart you should place the dots until the dots disappear altogether.

Figure 4-5 shows how to sketch straight lines.



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Figure 4-5.—Sketching straight lines.

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Technical Drawing and Sketching, Continued

Sketching arcs, circles, and ellipses

Sketching arcs, circles, and ellipses are very similar processes. Lightly drawing a box to the proportion of the desired arc, circle, or ellipse will help in its construction. Using combined movements of your wrist and fingers, make short counterclockwise strokes. When you must join arcs to straight lines, draw the straight lines first to locate the ends of the arcs.

Figure 4-6 illustrates the sketching of arcs and circles within a box.

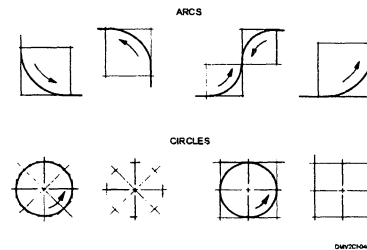


Figure 4-6.—Sketching arcs and circles.

You may also draw circles and ellipses using a trammel. A *trammel* is a length of cardboard or paper marked with both the major and minor axis of the desired ellipse. Place the trammel so that two of the points are on the respective axes. Mark the third point clearly since this point will form the curve on the paper. Place a dot periodically at the third point as you move the other two points along the axes. Place enough points to ensure a smooth and symmetrical ellipse. Sketch the ellipse lightly, then follow more heavily with the aid of irregular curves.

Figure 4-7 shows the use of a trammel.

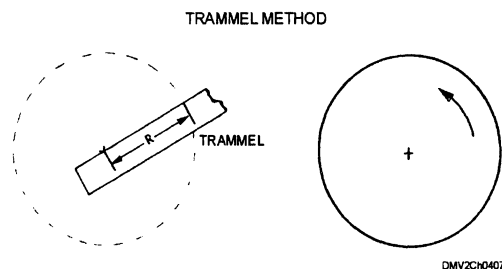


Figure 4-7.—Using a trammel to form a circle.

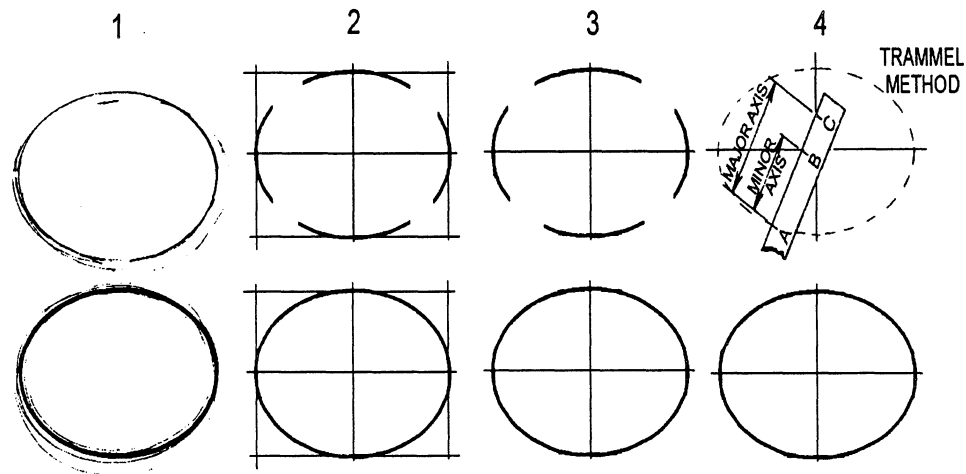
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Technical Drawing and Sketching, Continued

Sketching arcs, circles, and ellipses (Continued)

To sketch ellipses freehand, hold the pencil naturally and rest the weight of your hand on the upper part of your other forearm. With your hand raised slightly above the paper, move the pencil rapidly in an approximate elliptical path. Once in motion, lower the pencil to lightly sketch overlapping ellipses.

Figure 4-8 illustrates the steps involved in freehand sketching an ellipse.



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Figure 4-8.—Drawing ellipses.

Transferring or tracing images

When you need to transfer or trace images from one drawing to another or from one portion of a drawing to another location, you may transfer the image using a carbon or saral paper. When you have multiples of the same image and want to preserve some uniformity throughout their rendition, you will want to use this method. An easy way to transfer images when carbon or saral paper is not available is to color the backside of the paper or tracing with a contrasting color. Position the image into the new location and trace around its outline. The color on the reverse side of the image transfers the image to the paper.

Architectural/Structural Steel Drawings

Introduction

Architectural and structural drawings are drawings of steel, wood, concrete, and other materials used to construct buildings, ships, planes, bridges, towers, tanks, and so on. Building projects may be broadly divided into two major phases, the design phase and the construction phase. First, the architect conceives the project and sets the concept onto paper in the form of presentation drawings that are usually drawn in perspective by using pictorial drawing techniques. Next, the architect and engineer work together to decide upon construction materials and methods. The engineer determines the structural loads, mechanical, heating, lighting, and plumbing systems. The end result is the preparation of architectural and engineering design sketches that guide the draftsman who prepares the construction drawings. This section describes some common types of shapes and symbols used on architectural and structural drawings. For additional information in construction or building techniques, refer to the Seabee rate training manuals of *Engineering Aid* (EA), *Builder* (BU), and *Utilitiesman* (UT).

Shapes

Structural shapes common to construction materials are beams, channels, angles, tees, bearing piles, zees, plates, flat bars, and tie rod and pipe column. The American Society of Construction Engineers (ASCE) lists the symbols used to identify these shapes in bills of material, notes, or dimensions for military construction drawings in MIL-STD-18B.

BEAMS: A *beam* is a structural support. Beams are defined by their nominal depth in inches and weight per foot of length. There are wide-flange beams and I beams. The cross section of a wide-flange beam (WF) is in the form of the letter H and is the strongest most adaptable support structure. The cross section of I beams are in the shape of the letter I.

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Architectural/Structural Steel Drawings, Continued

Shapes (Continued)

Figure 4-9 shows the profile of a wide-flange beam.

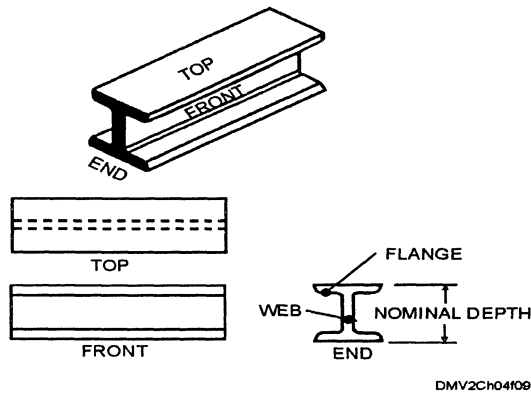


Figure 4-9.—The profile of a wide-flanged (H) beam.

CHANNELS: *Channels*, another structural support also defined by nominal depth and weight per foot, are principally used in locations where you need a single flat face without outstanding flanges on a side. A cross section of a channel is similar in shape to the squared letter C.

Figure 4-10 shows the profile of a channel.

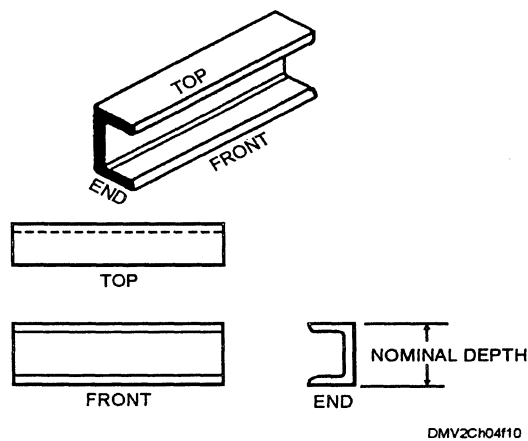


Figure 4-10.—The profile of a channel.

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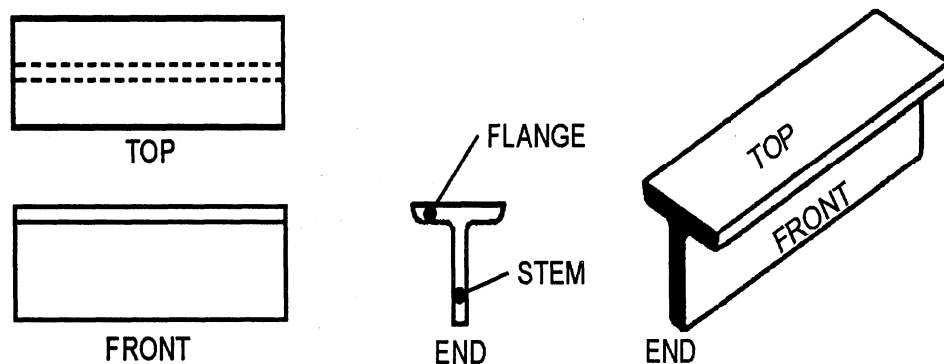
Architectural/Structural Steel Drawings, Continued

Shapes (Continued)

ANGLES: *Angle* supports are measured in inches with the width of the longer leg given first. The third dimension is the thickness of the leg. You may use angles singly or in combinations of two or four angles to form members. You can also use angles to connect main members or parts of members together. The shape of a cross section of an angle is in the form of the letter L.

TEES: A structural tee is a standard I- or H-beam cut through the center of the web, thus forming two tee shapes from each beam. The dimensions of the tee are preceded by the letter T.

Figure 4-11 shows the profile of a tee.



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Figure 4-11.—The profile of a tee.

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Architectural/Structural Steel Drawings, Continued

Shapes (Continued)

BEARING PILES: Bearing piles are the same as wide-flange H-beams, but are much heavier per linear foot.

ZEE: These shapes are noted by depth, flange width, and weight per linear foot.

PLATES: Plates are noted by width, thickness, and length.

FLATBAR: Flat bars are similar to plates with edges rolled square. The dimensions are given for width and thickness.

TIE ROD AND PIPE COLUMN: Tie rods and pipe columns are designated by their outside diameters.

Members

The main parts of a structure are the load-bearing structural *members* that support and transfer loads on the structure while remaining in equilibrium with each other. The places where members connect are called *joints*. The total load supported by the structural members at a particular instant is equal to the total dead load plus the total live load. The ability of the earth to support a load is called the *soil-bearing capacity*.

TOTAL DEAD LOAD: The *total dead load* is the total weight of the structure, which gradually increases as the structure rises and remains constant after the construction is completed.
















TOTAL LIVE LOAD: The *total live load* is the total weight of moveable objects, such as people, furniture, and traffic that the structure supports at any particular time.

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Architectural/Structural Steel Drawings, Continued

Shape symbols The following list contains the symbols for single structural shapes.

Figure 4-12 lists common symbols for single structural shapes.

DESCRIPTION	PICTORIAL	MIL-STD SYMBOL	ILLUSTRATED USE	AISC SYMBOL	ILLUSTRATED USE
WIDE FLANGE SHAPE		WF	24 WF 76	W	W24 X 76
BEAMS AMERICAN STANDARD LIGHT BEAMS AND JOISTS STANDARD MILL JUNIOR		I B M Jr	15 I 42.9 6B 12 8M 17 7 Jr 5.5	S	S15 X 14.29
LIGHT COLUMNS		M	8 X 8M 34.3	M	M8 X 34.3
CHANNELS AMERICAN STANDARD CAR AND SHIP JUNIOR		Jr	9 X 13.4 12 X 4 44.5 10 Jr 8.4	C	C9 X 13.4
ANGLES EQUAL LEG		L	L 3 X 3 X $\frac{1}{4}$	L	L 3 X 3 X $\frac{1}{4}$
UNEQUAL LEG		L	L 7 X 4 X $\frac{1}{2}$	L	L 7 X 4 X $\frac{1}{2}$
BULB		BULB L	BULB L 6 X 3 $\frac{1}{2}$ X 17.4		
TEES STRUCTURAL ROLLED		ST T	ST 5 WF 10.5 T 4 X 3 X 9.2	WT	WT 12 X 38
BEARING PILE		BP	14 BP 73	HP	HPI 4 X 73
ZEE		Z	Z 6 X 3 $\frac{1}{2}$ X 15.7		
PLATE		PI	PI 18 X $\frac{1}{2}$ X 2'-6"	PL	PL 18 X $\frac{1}{2}$ X 2'-6"
FLAT BAR		Bar	Bar 2 $\frac{1}{2}$ X $\frac{1}{4}$	Bar	Bar 2 $\frac{1}{2}$ X $\frac{1}{4}$
TIE ROD		TR	$\frac{3}{4}$ ϕ TR		
PIPE COLUMN		O	O 6 ϕ		pipe 4 std

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Figure 4-12.—Symbols for single structural shapes.

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Architectural/Structural Steel Drawings, Continued

Vertical members

Vertical structural members extend from footings or a foundation to the roof line. High strength vertical members are called *columns* or *pillars*. Short columns or *piers* rest directly on footings or may be set into the ground. On bridge structures, piers provide intermediate support for the bridge superstructure. In light-frame and wood constructions, vertical structural members are called studs. *Sills* or sole plates are horizontal members that support the bottom of studs on the foundations while *rafter plates*, *top plates* or *stud caps* anchor the top. Enlarged or combined studs at a corner position are referred to as *corner posts*.

Figure 4-13 shows light-frame vertical members.

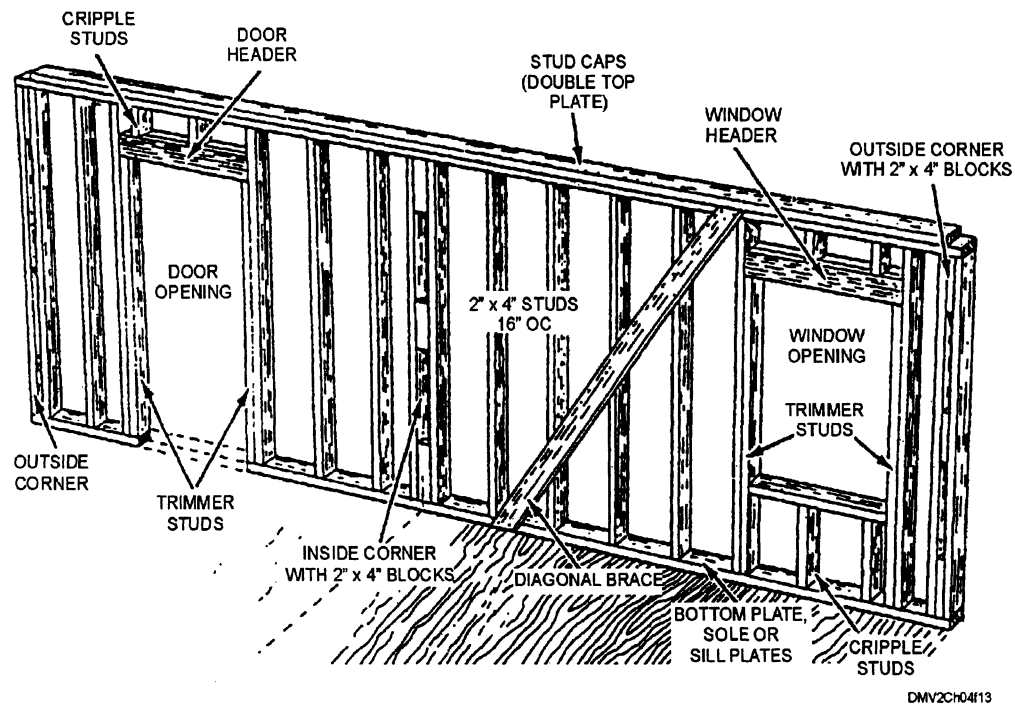


Figure 4-13.—Vertical members of a light-frame (wood) construction.

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Architectural/Structural Steel Drawings, Continued

Horizontal members

Beams are horizontal load-bearing members supported at both ends. When only one end is fixed, it is called a *cantilever*. Horizontal members that support the weight of concrete or masonry walls above door and window openings are called *lintels*. *Sills*, *girts*, or *girders* support the ends of floor beams in wood-construction. Sills, sole plates, stud caps, rafter plates, and top plates are horizontal members and were discussed in the previous paragraph.

Figure 4-14 show examples of a cantilever and a lintel.

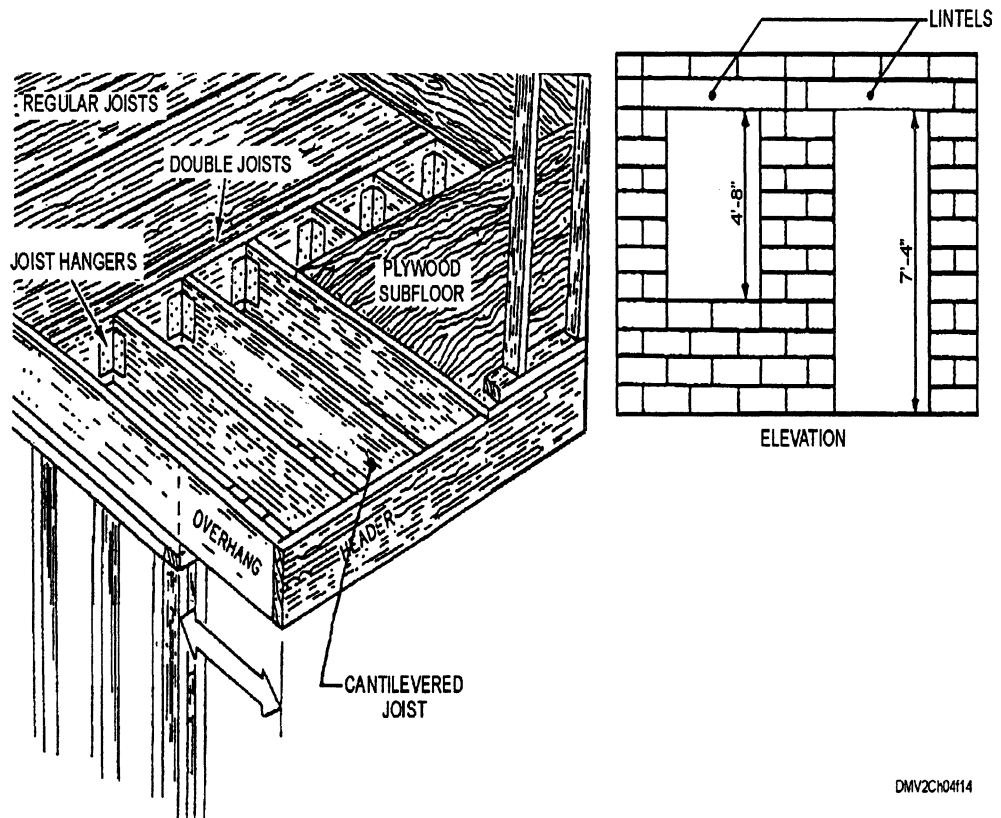


Figure 4-14.—Examples of joists: (A) A cantilever; and (B) A lintel.

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Architectural/Structural Steel Drawings, Continued

Trusses

A *truss* is framework consisting of two horizontal (or nearly horizontal) members joined by a number of vertical and/or inclined members to form a series of triangles. The horizontal members are called the *upper* or *top* and *bottom* or *lower chords*. The vertical and/or inclined members that connect the upper and lower chords are called *web members*. Use trusses when the maximum given load exceeds the rated strength of a beam.

Figure 4-15 illustrates the terminology of a truss.

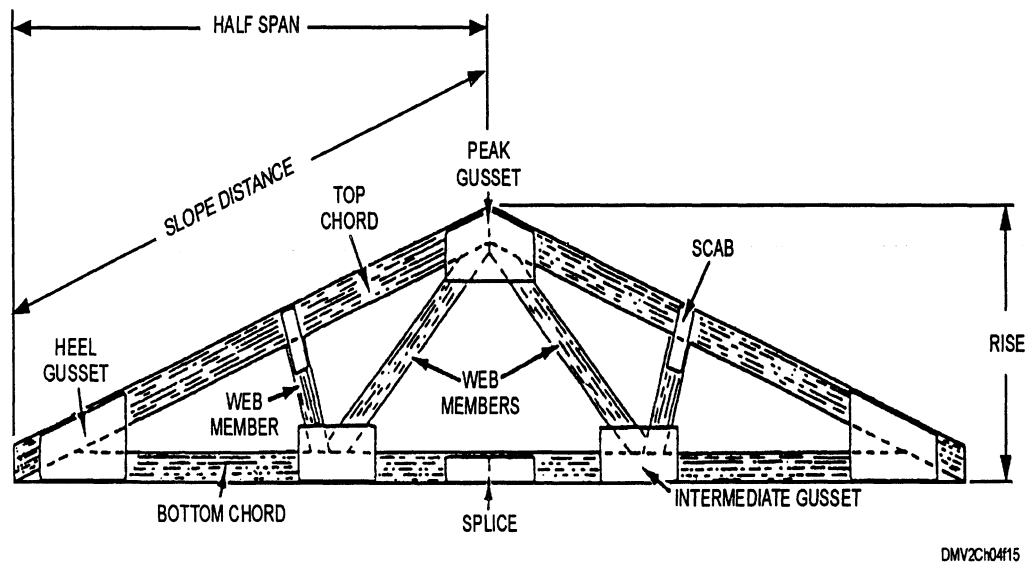


Figure 4-15.—Truss nomenclature.

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Architectural/Structural Steel Drawings, Continued

Steel truss construction

Steel structures use trusses that are either welded or riveted. Welded steel construction is more flexible than riveted construction. In both cases some welding or riveting is done in the shop and some in the field. Weld or rivet locations are premarked or predrilled. You should use standard welding or riveting symbols on your drawings.

Welding symbology

Eight elements comprise each welding symbol. The *reference line* or *base* (A) is the foundation for all other elements. The arrowhead (B) points to the location of the weld. Center the basic weld symbol (C) (a fillet weld in this case) on the base on the arrow side of the object being welded. The dimension and the length of the weld (D) appear near the weld. Supplementary symbols cap the basic weld symbol (E). This is the symbol for a convex weld and finish markings (F) indicate the degree of finish. The tail of the weld symbol (G) sets off symbols that show certain processes, specifications, or references. Omit the tail if no special instructions exists. Inside the tail, place the symbol or abbreviation (H) that represents the process, specification, or reference. This completes the eight elements of a basic welding symbol.

Figure 4-16 shows the elements of a basic weld symbol.

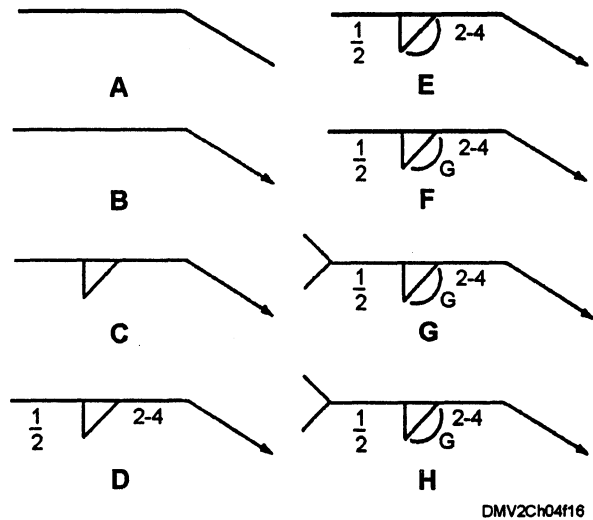


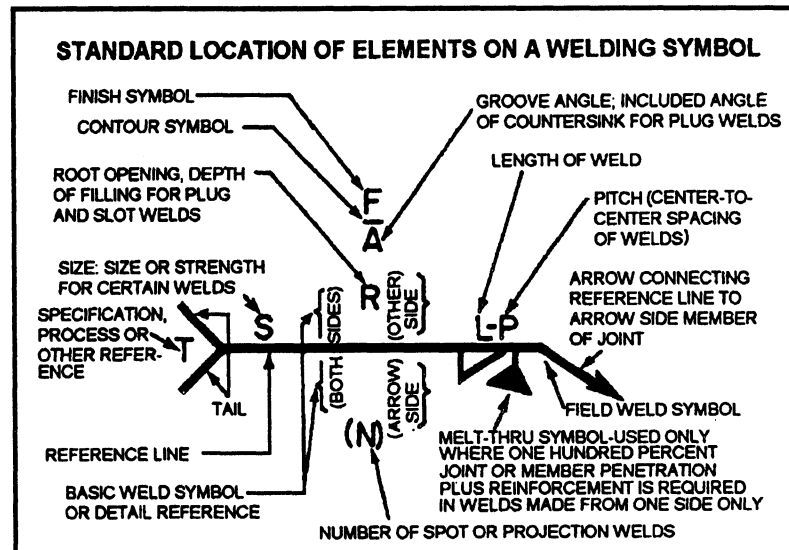
Figure 4-16.—The eight elements of a basic welding symbol.

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Architectural/Structural Steel Drawings, Continued

Welding symbology (Continued)

Figure 4-17 is a legend of standard location of elements and types of welding symbols.



BASIC ARC AND GAS WELD SYMBOLS							
BEAD	FILLET	PLUG OR SLOT	GROOVE				
			SQUARE	V	BEVEL	U	J

BASIC WELD SYMBOLS				SUPPLEMENTARY WELD SYMBOLS				
SPOT	PROJECTION	SEAM	FLASH OR UPSET	WELD ALL AROUND	FIELD WELD	CONTOUR		
						FLUSH	CONVEX	CONCAVE

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Figure 4-17.—Standard locations of elements and types of welding symbols.

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Architectural/Structural Steel Drawings, Continued

Welding symbology (Continued)

Figure 4-18 is a chart showing the application of welding symbols.

	APPLICATION	DESIRED WELD	SECTION OR END	ELEVATION	PLAN
SYMBOLS FOR FILLET, SQUARE GROOVE, AND BEVEL GROOVE WELDS	ARROW-SIDE FILLET WELD				
	OTHER-SIDE FILLET WELD				
	BOTH-SIDES FILLET WELD, ONE JOINT				
	BOTH-SIDES FILLET WELD, TWO JOINTS				
	ARROW-SIDE SQUARE GROOVE WELD				
	BOTH-SIDES SQUARE GROOVE WELD				
	ARROW-SIDE BEVEL GROOVE WELD				
	BOTH-SIDES BEVEL GROOVE WELD				
SYMBOLS FOR V-GROOVE, J-GROOVE AND U-GROOVE WELDS	ARROW-SIDE V-GROOVE WELD				
	BOTH-SIDES V-GROOVE WELD				
	ARROW-SIDE J-GROOVE WELD				
	BOTH-SIDES J-GROOVE WELD				
	ARROW-SIDE U-GROOVE WELD				
	BOTH-SIDES U-GROOVE WELD				

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Figure 4-18.—The application of welding symbols.

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Architectural/Structural Steel Drawings, Continued

Rivet symbology

Rivet locations are predrilled or punched. Some rivet are driven at the shop, others are made at the jobsite. In either case, you should correctly locate and identify rivet connections on the fabrication drawings.

Figure 4-19 is a description and symbol for common rivet joints.

<i>Description</i>	<i>Plan</i>	<i>Section</i>
Shop rivets		
Two full heads		
Countersunk & chipped NS		
Countersunk & chipped FS		
Countersunk & chipped BS		
Countersunk, not over 1/8 inch high NS		
Countersunk, not over 1/8 inch high FS		
Countersunk, not over 1/8 inch high BS		
Flattened to 1/8 inch for 1/2 and 3/4 rivets NS		
Flattened to 1/8 inch for 1/2 and 3/4 rivets FS		
Flattened to 1/8 inch for 1/2 and 3/4 rivets BS		
Flattened to 1/8 inch for 1/2 and over rivets NS		
Flattened to 1/8 inch for 1/2 and over rivets FS		
Flattened to 1/8 inch for 1/2 and over rivets BS		
Field rivets		
Two full heads		
Countersunk NS		
Countersunk FS		
Countersunk BS		
Notes : NS-near side. FS-far side. BS-both sides.		

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Figure 4-19.—Riveting symbols.

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Architectural/Structural Steel Drawings, Continued

Drawing steel structures

Blueprints used in the fabrication and erection of steel structures consist of a group of different types of drawings, such as layout, general, fabrication, erection, and falsework.

LAYOUT DRAWINGS: *Layout drawings*, often called *general plans* or *profile drawings*, provide information on the location, alignment, and elevation of a structure and its principal parts in relation to the ground site. They may also provide information on the nature of underlying soil or the location of adjacent structures or roads. Written specifications usually supplement layout drawings.

GENERAL PLANS: *General plans* contain information on the size, material, and makeup of all main members of the structure, their relative position and method of connection, as well as the attachment of other parts of the structure. They consist of plan views, elevations, and sections of the structure and its various parts.

FABRICATION DRAWINGS: *Fabrication* or *shop drawings* contain all the necessary information on the size, shape, material, and provisions for connection and attachments for each member. There is sufficient detail to order material and begin construction.

ERECTION DRAWINGS: *Erection drawings* or *erection diagrams* show the location and position of various members in the finished structure. They are particularly helpful in the field when they show the approximate weight of heavy pieces and the number of pieces.

FALSEWORK DRAWINGS: *Falsework drawings* are drawing that show temporary supportive construction necessary to the erection or construction of difficult or complicated structures.

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Architectural/Structural Steel Drawings, Continued

Construction drawings

Construction drawings are orthographic views that present as much information as possible graphically or by pictures. They consist of plan views, elevations, section views, details, and specifications all on a relatively large scale.

PLAN Views: *Plan views* are views of the structure as it would appear if projected onto a horizontal plane passed through or held above the structure area. The most common construction plans are plot plans (also called site plans), foundation plans, floor plans, and framing plans. *Plot or site plans* show the contours, boundaries, roads, utilities, trees, structures, and other significant physical features about structures on the site. *Foundation plans* are plan views of a structure projected on an imaginary horizontal plane passing through at the level of the tops of the foundation. The information on a *floor plan* includes the lengths, thicknesses, and character of the building walls on that particular floor, the widths and locations of door and window openings, the length and character of partitions, the number and arrangement of rooms, and the types and locations of utility installations. *Framing plans* show the dimension numbers and arrangement of structural members in wood-frame construction.

Figure 4-20 is an example of a floor plan.

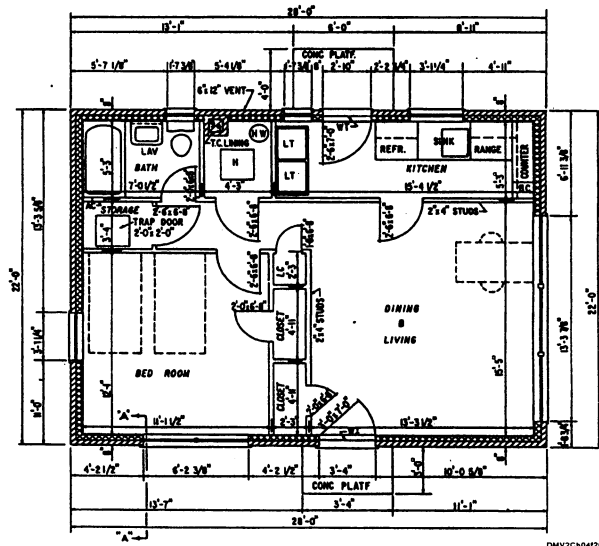


Figure 4-20.—A floor plan.

Continued on next page

Architectural/Structural Steel Drawings, Continued

Construction
drawings
(Continued)

Figure 4-21 shows graphic symbols used on architectural floor plans.

DOOR SYMBOLS	
TYPE	SYMBOL
SINGLE-SWING WITH THRESHOLD IN EXTERIOR MASONRY WALL	
SINGLE DOOR, OPENING IN	
DOUBLE DOOR, OPENING OUT	
SINGLE-SWING WITH THRESHOLD IN EXTERIOR FRAME WALL	
SINGLE DOOR, OPENING OUT	
DOUBLE DOOR, OPENING IN	
REFRIGERATOR DOOR	

WINDOW SYMBOLS			
TYPE	SYMBOL		
	WOOD OR METAL SASH IN FRAME WALL	METAL SASH IN MASONRY WALL	WOOD SASH IN MASONRY WALL
DOUBLE-HUNG			
CASEMENT			
DOUBLE, OPENING OUT			
SINGLE, OPENING IN			

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DMV2Ch04f21

Figure 4-21.—Architectural symbols.

Continued on next page

Architectural/Structural Steel Drawings, Continued

Construction drawings (Continued)

ELEVATIONS: *Elevations* show the front, rear, and sides of a structure. Elevations give you important vertical distances such as the location and characteristics of doors and windows. Dimensions of window sashes and the dimensions and character of lintels are usually set forth in a window schedule.

SECTION VIEWS: A section view is a cross section of a structure usually confined to views cut by vertical planes.

Figure 4-22 is an example of a section view for a wall.

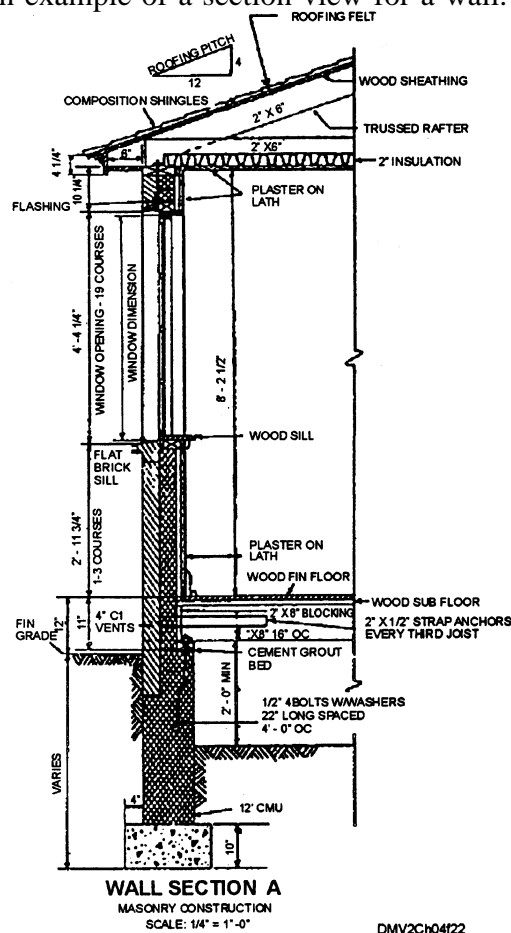


Figure 4-22.—A wall section.

Continued on next page

Architectural/Structural Steel Drawings, Continued

Construction drawings (Continued)

DETAIL DRAWINGS: *Detail drawings* show features that do not appear or appear too small on any other type of drawing. They are drawn at considerably larger scale than other drawings. Include detail drawings whenever the information given in the plans, elevations, and wall sections are insufficiently detailed to guide a craftsman on the job.

SPECIFICATION DRAWINGS: *Specification drawings* are not really drawings at all, but a list of written specifications. Specifications usually begin with a section on general conditions or description of the building including type of foundation, types of windows, character of framing, utilities installations, and so on. A list of definitions of terms used in the specs comes next, followed by certain routine declarations of responsibility.

Electrical/Electronic Drawings

Introduction

The major difference in electrical prints and electronic drawings is that electronic drawings are usually more difficult to read because they show more complex circuitry and systems. Interpreting either electronic or electrical prints requires you to recognize and understand the graphics symbols for electrical diagrams and the electrical wiring equipment symbols shown in *Graphic Symbols for Electrical and Electronic Diagrams*, ANSI Y32.2, and *Electrical Wiring Equipment Symbols for Ships' Plans*, Part 2, MIL-STD-15-2.

Electrical drawings

The Navy uses electrical drawings for shipboard electrical equipment and systems, shore-based power, lighting, and communications equipment, and aircraft electrical equipment and systems. Electrical drawings may be further divided into pictorial wiring diagrams, isometric wiring diagrams, single-line diagrams, schematic diagrams, elementary wiring diagrams, and block diagrams.

PICTORIAL WIRING DIAGRAMS: *Pictorial wiring diagrams* are pictorial sketches of various parts of an item of equipment and the electrical connections between the parts.

ISOMETRIC WIRING DIAGRAMS: An *isometric wiring diagram* shows the outline of a ship or aircraft or other structure and the location of equipment such as panels, connection boxes, and cable runs.

SINGLE-LINE DIAGRAMS: Lines and graphic symbols simplify complex circuits or systems in a *single-line diagram*.

SCHEMATIC DIAGRAMS: A *schematic diagram* shows how a circuit functions electronically.

ELEMENTARY WIRING DIAGRAMS: *Elementary wiring diagrams* show in simplest form how each individual conductor connects to various connection boxes of an electrical circuit or system.

BLOCK DIAGRAMS: Major equipment components or systems reduced to simple geometric form and displayed in normal order of progression of signal or current flow by single lines comprise *block diagrams*.

Continued on next page

Electrical/Electronic Drawings, Continued

Shipboard electrical prints	To better understand electrical/electronic prints used on board Navy ships, you should first familiarize yourself with the numbering system for electrical units.
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Numbering electrical units	<p>All similar electrical units on a ship comprise a group. Each group has a separate series of consecutive numbers beginning with 1. Numbering begins with units in the lowest foremost starboard compartment and continues with the next compartment to port if it contains similar units; otherwise it continues to the next aft compartment on the same level. Proceeding from starboard to port and from forward to aft, the numbering system continues until all similar units on the same level are numbered. It then begins again on another level until all levels are numbered. Additional general rules for numbering electrical units are as follow:</p> <ul style="list-style-type: none">● Within a given compartment, lower takes precedence over upper, forward over aft, and starboard over port.● Electrical distribution panels, control panels, and so forth, are given identification numbers made up of three numbers separated by hyphens. The first number identifies the vertical level by deck or platform number at which the panel is normally accessible. The second number identifies the longitudinal location of the unit by frame number. The third number identifies the transverse location by the assignment of consecutive odd numbers for centerline and starboard locations and consecutive even numbers for port locations.● Main switchboards or switch gear groups supplied directly from ship's service generators are designated with the suffix S. For example 1S, 2S, and so forth.● Switchboards supplied directly by emergency generators are designated 1E, 2E and so on.● Switchboards for special frequencies (other than the frequency of the ship's service system) have alternating current (ac) generators designated 1SF, 2SF, and so on.
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Continued on next page

Electrical/Electronic Drawings, Continued

Zone control numbers

Larger ships are numbered according to a zone control system. This system generally coincides with the fire zones prescribed by the ship's damage control plan. Load center switchboards distribute electrical power within each zone. Load center switchboards and miscellaneous switchboards on ships with zone control distribution are given identification numbers. The first number represents the zone, and the second number represents the switchboard within the zone.

Cable markings

Cable labels are metal tags embossed with identification numbers attached to cable wire as close as practical to each point of connection on both sides of decks, bulkheads, and barriers. There are two systems for marking electrical cables on ships. The old system of cable markings appear on ships built before 1949. The tags are red (vital), yellow (semivital), and grey (nonvital). Letter designators identify power and lighting cables for different services. The new cable tag system appears on ships built after 1949. The new system consists of three parts in sequence: source, voltage, and service. When practical, destination may also appear on the tag.

Figure 4-23 is an example of a marked cable tag.

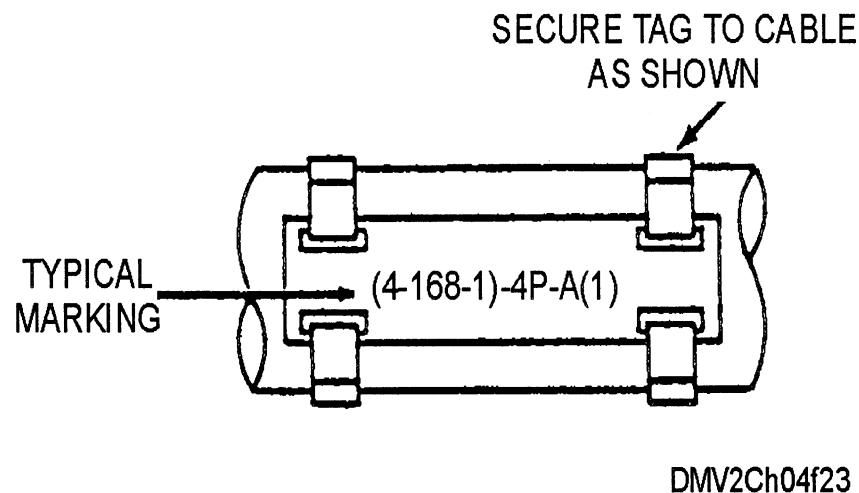


Figure 4-23.—A cable tag.

Continued on next page

Electrical/Electronic Drawings, Continued

Cable markings The following list shows new cable tag designators:
(Continued)

Letter	Function
C	Interior communications
D	Degaussing
G	Fire control
K	Control power
L	Ship's service lighting
N	Navigational lighting
P	Ship's service power
R	Electronics
CP	Casualty power
EL	Emergency lighting
EP	Emergency power
FL	Night flight lights
MC	Coolant pump power
MS	Minesweeping
PP	Propulsion power
SF	Special frequency power

Continued on next page

Electrical/Electronic Drawings, Continued

Isometric wiring diagrams (shipboard)	Isometric wiring diagrams show an entire circuit system layout. It shows each deck of the ship arranged in tiers, bulkheads and compartments, a marked centerline, frame numbers for every five frames, and the outer edge of each deck in a general outline of the ship. All athwartship lines make an angle of 30 degrees to the centerline and cables that run from one deck to another are drawn at right angles to the centerline. A single line represents a cable regardless of the number of connectors.
Single-line diagrams (shipboard)	Single-line diagrams show a general description of a system and how the system functions. More detailed than block diagrams, they require less supporting text.
Schematic diagrams (shipboard)	Electrical schematic diagrams describe the electrical operation of a particular piece of equipment, circuit, or system. It is not drawn to scale and usually does not show the relative positions of various components.
Elementary wiring diagrams (shipboard)	Elementary wiring diagrams show in detail each conductor, terminal, and connection in a circuit. It also shows conductor markings alongside each conductor and how they connect in a circuit. Elementary wiring diagrams are not drawn to any scale.
Wiring deck plan (shipboard)	Wiring deck plans are peculiar to ship electrical systems and show the actual installation diagram for the deck or decks shown in increments of 150 to 200 linear feet. Drawn to scale (usually 1/4 inch to the foot), they show the exact location of all fixtures. Wiring deck plans include a bill of material and a list of all necessary equipment to complete the job.
Equipment wiring diagram (shipboard)	Equipment wiring diagrams show relative positions of various components of equipment and how each individual conductor connects to the circuit. You will need wiring diagrams for various pieces of equipment in a system for troubleshooting electrical failures.
Block diagrams (shipboard)	Block diagrams of electrical systems show major units of the system in block form. Used with text material, they provide a general description of the system and its function.

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Electrical/Electronic Drawings, Continued

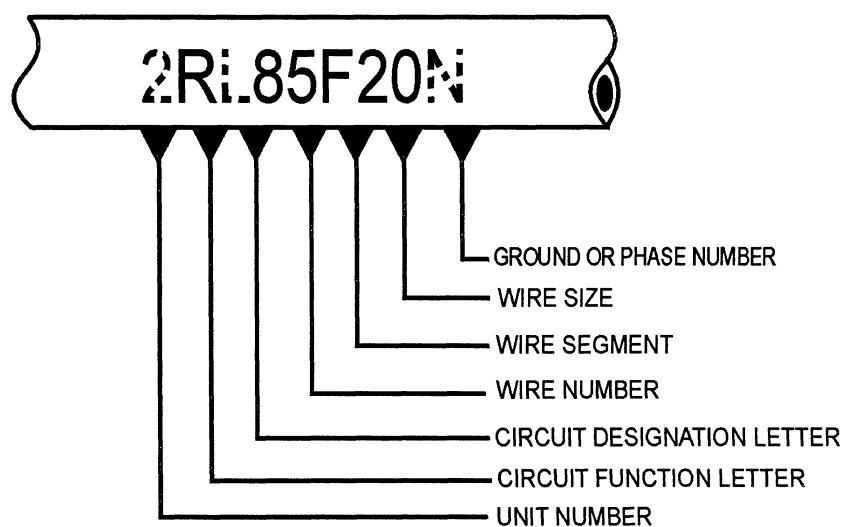
Aircraft electrical prints

Aircraft electrical prints include schematic diagrams and wiring diagrams. Similar to shipboard schematics, aircraft schematics show electrical operations. Aircraft wiring diagrams show detailed circuit information on all electrical systems. A master wiring diagram is a single diagram that shows all the wiring in the aircraft. Diagrams of major circuits generally include an isometric wiring diagram showing the location of equipment and the routing of interconnecting cables. The simplified wiring diagram details how each component connects to the system. Circuit wiring diagrams give equipment part numbers, wire numbers, and all terminal strips and plugs.

Aircraft wire identification coding

All aircraft wiring is identified on wiring diagrams exactly as it appears in the aircraft. A code identifies each wire combining letters and numerals imprinted at prescribed intervals along the wire run.

Figure 4-24 outlines the elements of aircraft wire identification designations.



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Figure 4-24.—Aircraft wire identification.

Continued on next page

Electrical/Electronic Drawings, Continued

Aircraft wire identification coding (Continued)

The following list shows circuit function codes for aircraft wiring:

Letter	Function
A	Armament
B	Photographic
C	Control surface
D	Instrument
E	Engine instrument
F	Flight instrument
G	Landing gear
H	Heating, ventilating, and deicing
J	Ignition
K	Engine control
L	Lighting
M	Miscellaneous
P	DC power- dc power or power control system
Q	Fuel and oil
R	Radio (navigation and communications), RN- navigation, RP-intercommunications, RZ- interphones, headphones
S	Radar, SA-altimeter, SN-navigation, SQ-track, SR- recorder, SS-search
T	Special electronic, TE-countermeasures, TN- navigation, TR-receivers, TX-television transmitters, TZ-computers

Continued on next page

Electrical/Electronic Drawings, Continued

Aircraft wiring identification coding (Continued)

Part	Function
V	DC power and dc control wires for ac systems
W	Warning and emergency
X	AC power
Y	Armament special systems

Electronic prints

Electronic prints include isometric wiring diagrams, elementary wiring diagrams, block diagrams, schematic diagrams, and interconnection diagrams. The functions of electronic prints and electrical prints are the same except that electronic prints are generally harder to read because they are more detailed and complex. Electronic prints often appear with color coded wiring as shown in the following list:

Circuit	Color
Grounds, grounded elements and returns	Black
Heaters or filaments, off ground	Brown
Power supply, B plus	Red
Screen grids	Orange
Cathodes	Yellow
Control grids	Green
Plates	Blue
Power supply, minus	Violet
AC power lines	Grey
Miscellaneous, above or below ground returns	White

Continued on next page

Electrical/Electronic Drawings, Continued

Interconnection diagrams (shipboard)

Interconnection diagrams show cabling between electronic units and how the units interconnect. All terminal boards are assigned reference designation according to a unit numbering system.

Reference designations

A *reference designation* is a combination of letters and numbers used to identify the various parts and components on electronic drawings, diagrams, and parts lists. Reference designations are assigned beginning with the unit and continuing down to the lowest level (part). Units begin with the number 1 and continue with consecutive numbers for all units of a set. Assemblies and subassemblies are assigned reference designators beginning with the unit number, the letter A to indicate an assembly or subassembly, and a specific number. Parts are assigned Reference designations for parts that consist of a unit and assembly or subassembly designation plus a letter or letters identifying the class to which the part belongs and a specific number. For each additional subassembly, another letter A and number are added to the part reference designation. In the prints you work with the drawings reference designation will comply with a system called the unit numbering system.

Unit numbering system

The *unit numbering system* is the reference designation system used to identify electronic systems that are broken into sets, units, assemblies, subassemblies, and parts. A *system* is defined as two or more sets and other assemblies, subassemblies, and parts necessary to perform an operational function or functions. A *set* is one or more units and the necessary assemblies, subassemblies, and parts connected or associated together to perform an operational function.

Figure 4-25 shows a five-unit set.

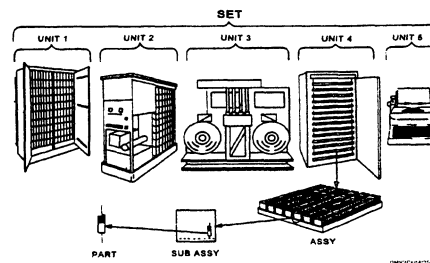


Figure 4-25.—A five-unit set.

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Electrical/Electronic Drawings, Continued

Aircraft electronic prints

Aircraft electronic prints include isometric wiring diagrams and block diagrams both simplified and detailed. The purpose and functions of these diagrams are similar to their shipboard counterpart. Aircraft electronic wiring diagrams fall into two basic classes: chassis wiring diagrams and interconnecting diagrams.

Electro-mechanical drawings

Electromechanical devices such as synchros, gyros, accelerometers, autotune systems, and analog computing elements are common in avionic systems. You need more than an electrical or electronic drawing to understand these systems; therefore, we use a combination of mechanical drawings and electronic or electrical drawings and call them *electromechanical drawings*. Electromechanical drawings show only those items essential to the operation of a particular piece of equipment or part.

Logic diagrams

Logic diagrams describe the operation and maintenance of digital computers. Simple logic operations used in digital computers are based on the theory in Boolean algebra that an element can be in only one of two possible states at any given time and that there are three basic operations, AND, OR, and NOT. The two states, represented by 0 and 1 respectively, correspond to the binary number systems consisting of the symbols 0 and 1. Computer operating terms NOR, NAND, INHIBIT, and EXCLUSIVE OR correspond to the basic AND, OR, and NOT.

Continued on next page

Electronic/Electrical Drawings, Continued

Logic diagrams Figure 4-26 is a table of logic operations comparisons and binary values.
(Continued)

FUNCTION	SWITCHING CIRCUIT	TRUTH TABLE	BLOCK DIAGRAM																																																		
AND		<table><tr><th>A</th><th>B</th><th>AB</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table>	A	B	AB	0	0	0	0	1	0	1	0	0	1	1	1																																				
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EXCLUSIVE OR		<table><tr><th>A</th><th>B</th><th>A+B</th><th>AB</th><th>$(A+B)\bar{AB}$</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td></tr></table> <table><tr><th>A</th><th>B</th><th>$A\bar{B}$</th><th>$\bar{A}B$</th><th>$A\bar{B} + \bar{A}B$</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr></table>	A	B	A+B	AB	$(A+B)\bar{AB}$	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	1	0	A	B	$A\bar{B}$	$\bar{A}B$	$A\bar{B} + \bar{A}B$	0	0	0	0	0	0	1	0	1	1	1	0	1	0	1	1	1	0	0	0	
A	B	A+B	AB	$(A+B)\bar{AB}$																																																	
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A	B	$A\bar{B}$	$\bar{A}B$	$A\bar{B} + \bar{A}B$																																																	
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Figure 4-26.—Logic operations comparison chart.

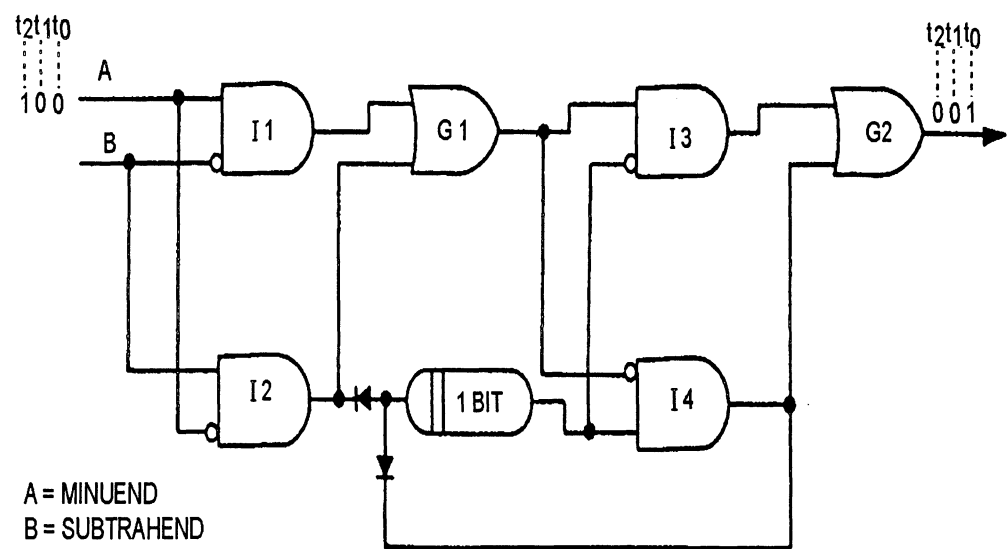
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Electrical/Electronic Drawings, Continued

Basic logic diagrams

Basic logic diagrams show the operation of particular units or components. Show basic logic symbols in their proper relationship to show operation only in the most simplified form possible.

Figure 4-27 show a basic logic diagram.



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Figure 4-27.—A basic logic diagram.

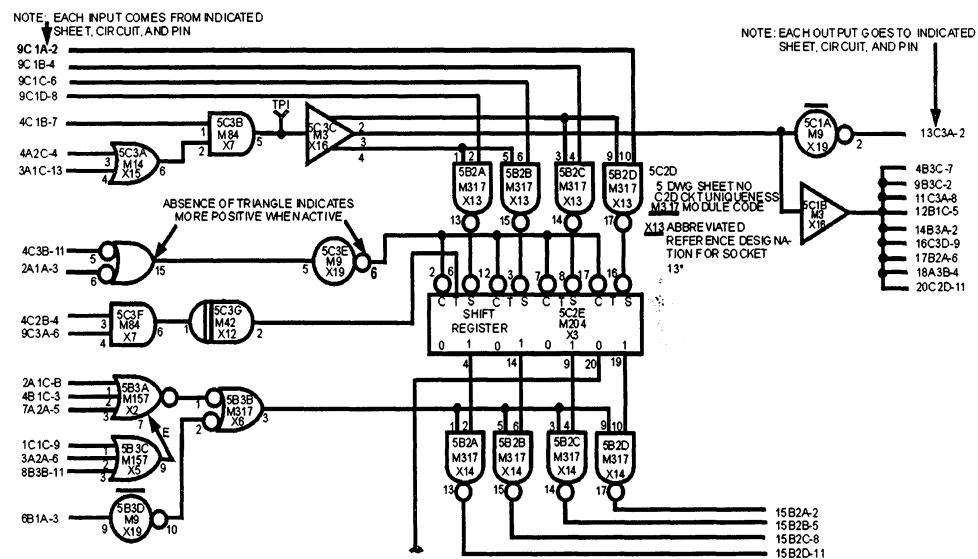
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Electrical/Electronic Drawings, Continued

Detailed logic diagrams

Detailed logic diagrams show all logic functions of the concerned equipment. Additionally, they include information such as socket locations, pin numbers, and test points to help in troubleshooting. A detailed logic diagram may consist of many separate sheets.

Figure 4-28 is an example of a detailed logic diagram.



DMV2Ch04f28

Figure 4-28.—A detailed logic diagram.

Machine Drawings

Introduction	In learning to draw and read machine drawings, you must first become familiar with common terms, symbols, and conventions. The following paragraphs cover common terms most used in all aspects of machine drawings.
Standards	American industry and the Department of Defense (DoD) follow the standard <i>Geometrical Dimensioning and Tolerancing</i> , ANSI Y14.5M-1982. This is the standard used in all blueprint production whether the master drawings are drawn by human hand or by computer-aided drawing (CAD) equipment. It standardizes the production of prints from the simplest hand-made job on site to single or multiple-run items produced in a machine shop with computer-aided manufacturing (CAM). Refer to ANSI Y14.5M-1982 when creating or altering machine drawings. Also refer to MIL-STD-9A for <i>Screw Thread Conventions and Methods of Specifying</i> , ANSI 46.1 for <i>Surface Textures</i> , and MIL-STD-12C for <i>Abbreviations for Use On Drawings and In Technical-Type Publications</i> .
General terms	<p>Tolerances, fillets and rounds, slots and slides, keys, keyseats, and keyways, screw threads, gears, helical springs, and finish marks present common problems to the draftsman. Standards offer uniform solutions to these problems.</p> <p>TOLERANCES: <i>Tolerancing</i> is a method of indicating acceptable variations in size or surface and appears as a minus or plus a certain amount stated in fractions or decimals. The minus or plus figures are the minimum and/or maximum value prescribed for a specific dimension. The three ways of showing tolerances are the <i>unilateral method</i> used when variation in design is permissible in one direction only, the <i>bilateral method</i>, which shows the acceptable minus or plus variations, and the <i>limiting dimensioning method</i>, which states both the allowable minimum and maximum measurements.</p>

Continued on next page

Machine Drawings, Continued

General terms (Continued) Figure 4-29 shows the methods of indicating tolerances.

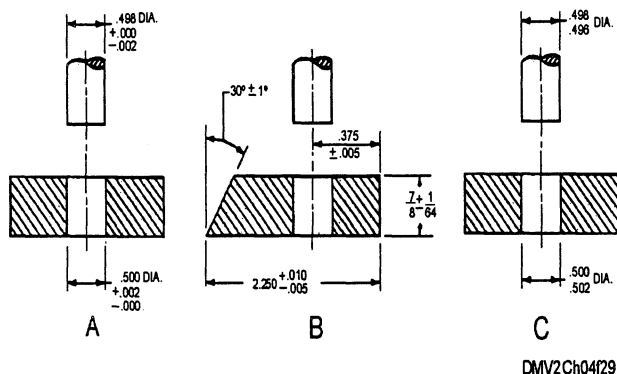


Figure 4-29.—Methods of indicating tolerance.

SURFACE TOLERANCES: Toleranced surfaces have certain geometric characteristics such as roundness or perpendicularity to other surfaces. A *feature control symbol* is made of geometric symbols and tolerances, which may include a datum reference and indicates surface tolerances. A *datum* is a surface, line, or point from which a geometric position is determined or from which a distance is measured.

Figure 4-30 illustrates a feature control frame indicating a datum reference.

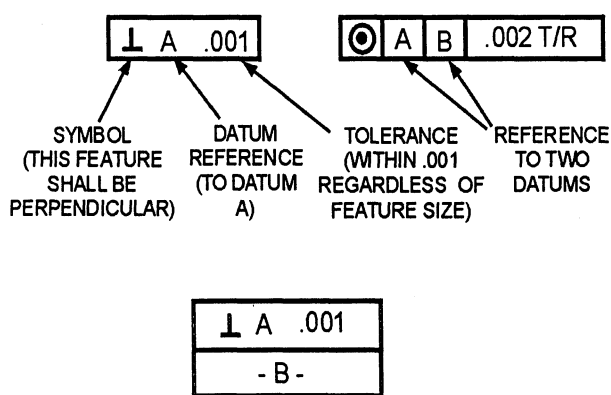













Figure 4-30.—Feature control frame indicating a datum reference.

Continued on next page

Machine Drawings, Continued

General terms
(Continued)

Figure 4-31 is a chart of general geometric characteristic symbols.

	FLATNESS & STRAIGHTNESS
	ANGULARITY
	PERPENDICULARITY
	PARALLELISM
	CONCENTRICITY
	TRUE POSITION
	ROUNDNESS
	SYMMETRY
	(MMC) MAXIMUM MATERIAL CONDITION
	(RFS) REGARDLESS OF FEATURE SIZE
	DATUM IDENTIFYING SYMBOL

DMV2Ch04f31

Figure 4-31.—Geometric characteristics symbols.

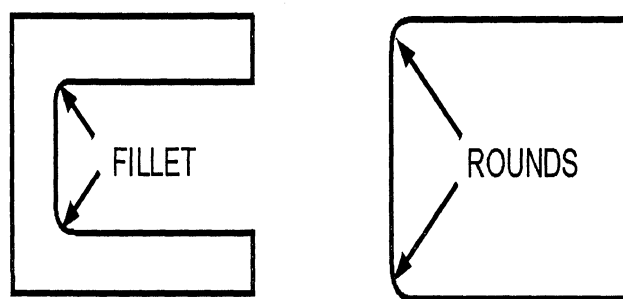
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Machine Drawings, Continued

General terms (Continued)

FILLETS AND ROUNDS: *Fillets* are concave metal (inside) corners. In cast objects, fillets strengthen the corners because they cool more evenly than sharp corners. *Rounds* are edges (outside corners) that are rounded to prevent chipping or sharp cutting edges.

Figure 4-32 shows examples of a fillet and a round.

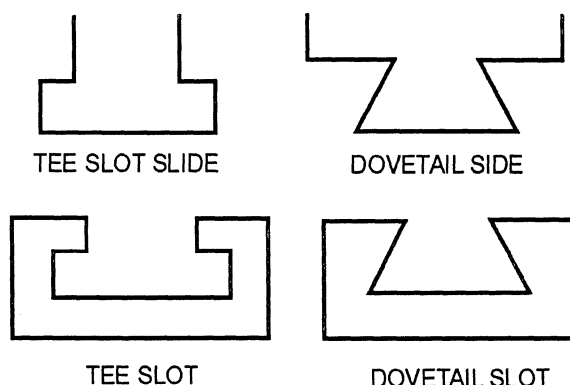


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Figure 4-32.—A fillet and a round.

SLOTS AND SLIDES: *Slots* and *slides* are two specially shaped pieces of material formed to mate together and hold secure while allowing lateral or sliding movement. The two types of slots are tee slots and dovetail slots.

Figure 4-33 shows tee and dovetail slots and slides.



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Figure 4-33.—Tee and dovetail slots and slides.

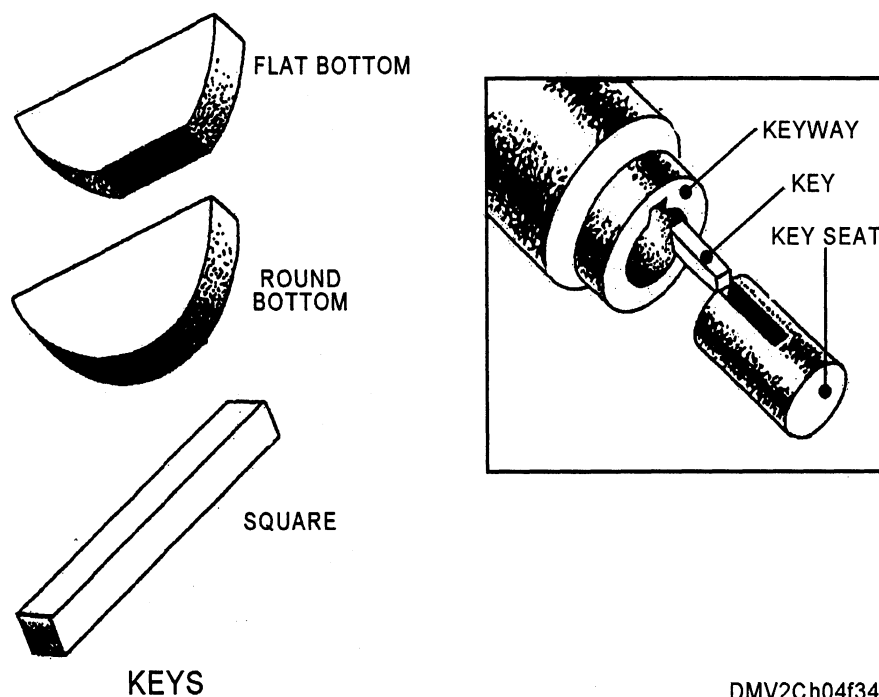
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Machine Drawings, Continued

General terms (Continued)

KEYS, KEYSEATS, AND KEYWAYS: A key is a small wedge or rectangular piece of metal inserted in a slot or groove between a shaft and a hub to prevent slippage. The three types of keys are the flat bottom, round bottom, and square. A *keyseat* is a groove into which a key fits. A *keyway* is an exterior sleeve surrounding the keyseat, which prevents movement of all parts.

Figure 4-34 shows keys, keyseats, and keyways.



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Figure 4-34.—Keys, keyseats, and keyways.

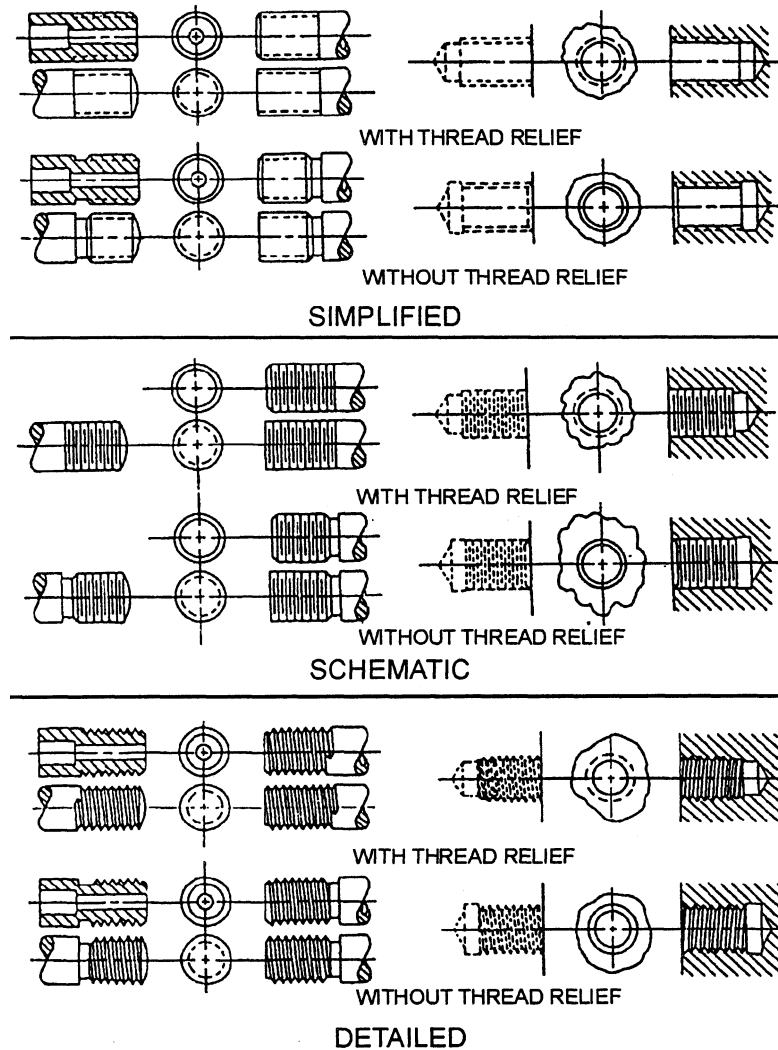
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Machine Drawings, Continued

General terms (Continued)

SCREW THREADS: Draftsmen use different methods to show threads on drawings. For some drawings, a simplified method of thread representation will suffice; for other drawings, you may have to represent thread by the schematic method or the detailed method.

Figure 4-35 shows the differences in thread representation.



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Figure 4-35.—Thread representation.

Continued on next page

Machine Drawings, Continued

General terms (Continued)

To save time, use symbols that are not drawn to scale. Show the dimensions on the threaded part and place other information on a note in the upper-left corner of the drawing. In our example, the note shows the thread designation of 1/4-20 UNC-2.

The first number of the note (1/4) is the nominal size, which is the outside diameter. The number after the first dash (20) means there are 20 threads per inch. The letters UNC identify the thread series as Unified National Course. The last number identifies the class of thread and tolerance commonly called the fit. If it is a left-hand thread, a dash and the letters LH follow the class of thread. Threads without the LH are right-hand threads.

Specifications for the manufacture of screws include thread diameter, number of threads per inch, thread series, and class of thread. The two most common screw thread series are the Unified or National Form Threads, which are called National Course or NC and National Fine (NF threads). NF threads have more threads per inch of screw length than NC.

The amount of tolerance and/or specified allowance distinguishes between classes of threads. Formerly known as class of fit, a new term, *class of thread* is now in use by the National Bureau of Standards in the *Screw-Thread Standards for Federal Services*, Handbook H-28.

Figure 4-36 show thread designation for an external thread.

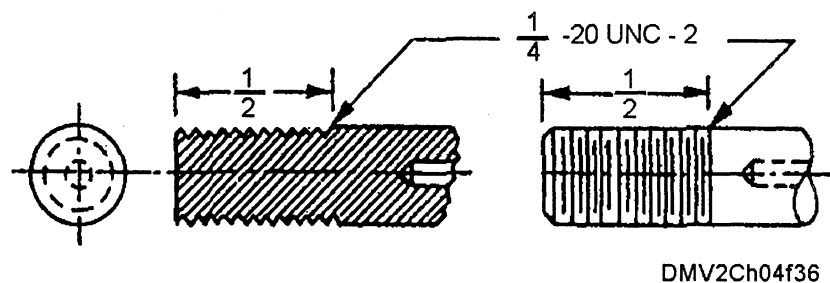


Figure 4-36.—External thread designations.

Continued on next page

Machine Drawings, Continued

General terms (Continued)

Terminology used to describe screw threads is a worldwide industry standard.

HELIX: The curve formed on any cylinder by a straight line in a plane wrapped around the cylinder with constant forward progression.

EXTERNAL THREAD: A thread on the outside.

INTERNAL THREAD: A thread on the inside.

MAJOR DIAMETER: The largest diameter of an external or internal thread.

AXIS: The centerline running lengthwise through a screw.

CREST: The surface of a thread corresponding to the major diameter of an external thread and the minor diameter of an internal thread.

ROOT: The surface of a thread corresponding to the minor diameter of an external thread and the major diameter of an internal thread.

DEPTH: The distance from the root of a thread to the crest measured perpendicularly to the axis.

PITCH: The distance from a point on a screw thread to a corresponding point on the next thread as measured parallel to the axis.

LEAD: The distance a screw thread advances on one turn as measured parallel to the axis. On a single-thread screw, the lead and the pitch are identical. On a double-thread screw, the lead is twice the pitch; on a triple-thread screw, the lead is three times the pitch.

Continued on next page

Machine Drawings, Continued

General terms
(Continued)

Figure 4-37 shows screw thread terminology and locations.

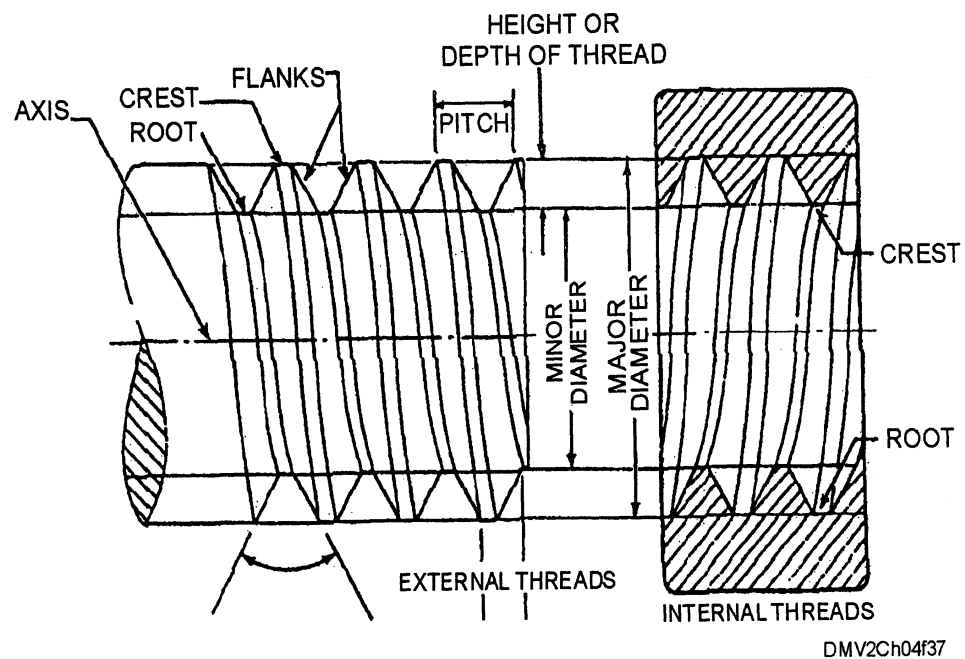


Figure 4-37.—Screw thread terminology.

Continued on next page

Machine Drawings, Continued

General terms (Continued)

GEARS: *Gears* transmit power and rotating or reciprocating motion from one machine part to another. When drawing gear teeth on machine drawings, draw only enough gear teeth to identify necessary dimensions.

Relate gear nomenclature with the terms in the figure.

PITCH DIAMETER (PD): The diameter of the pitch circle (or line), which equals the number of teeth on the gear divided by the diametral pitch.

DIAMETRAL PITCH (DP): The number of teeth to each inch of the pitch diameter or the number of teeth on the gear divided by the pitch diameter. Diametral pitch is usually referred to simply as **PITCH**.

NUMBER OF TEETH (N): The diametral pitch multiplied by the diameter of the pitch circle ($DP \times PD$).

ADDENDUM CIRCLE (AC): The circle over the tops of the teeth.

OUTSIDE DIAMETER (OD): The diameter of the addendum circle.

CIRCULAR PITCH (CP): The length of the arc of the pitch circle between the centers or corresponding points of adjacent teeth.

ADDENDUM (A): The height of the tooth above the pitch circle or radial distance between the pitch circle and the top of the tooth.

DEDENDUM (D): The length of the portion of the tooth from the pitch circle to the base of the tooth.

CHORAL PITCH: The distance from center to center of teeth measured along a straight line or chord of the pitch circle.

ROOT DIAMETER (RD): The diameter of the circle at the root of the teeth.

CLEARANCE (C): The distance between the bottom of the tooth and the top of a mating tooth.

Continued on next page

Machine Drawings, Continued

General terms (Continued)

WHOLE DEPTH (WD): The distance from the top of the tooth to the bottom, including the clearance.

FACE: The working surface of the tooth over the pitch line.

THICKNESS: The width of the tooth, taken as the chord of the pitch circle.

PITCH CIRCLE: The circle having the pitch diameter.

WORKING DEPTH: The greatest depth to which a tooth of one gear extends into the tooth space of another gear.

RACK TEETH: Compare a rack to a spur gear that is straightened out, then the linear pitch of the rack teeth equals the circular pitch of the mating gear.

Figure 4-38 illustrates gear nomenclature.

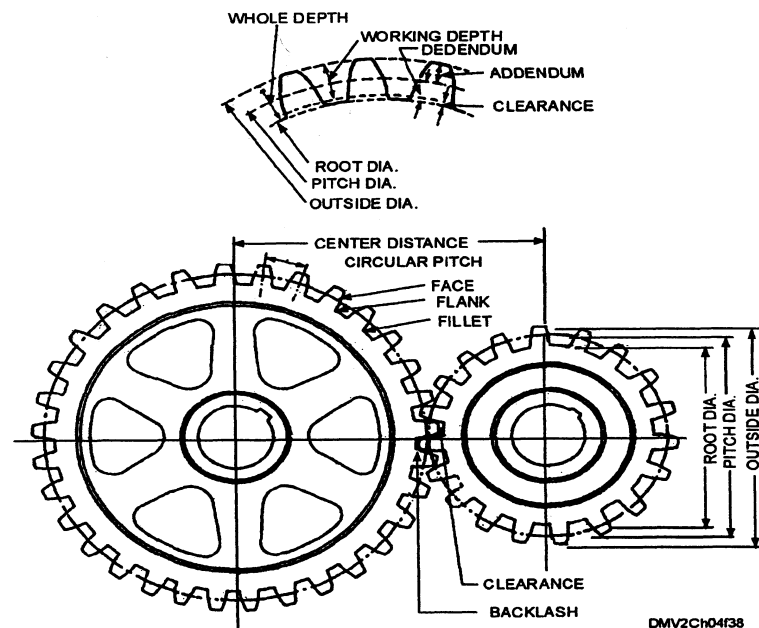


Figure 4-38.—Gear nomenclature.

Continued on next page

Machine Drawings, Continued

General terms (Continued)

HELICAL SPRINGS: *Helical springs* are mechanical devices designed to store energy by compression, extension, or torsion and return an equivalent amount of energy when released. Drawings seldom show a true representation of the helical shape. Draw helical springs on machine drawings with detailed or schematic (single-line) representation.

Figure 4-39 shows detailed and single-line representations of helical springs.

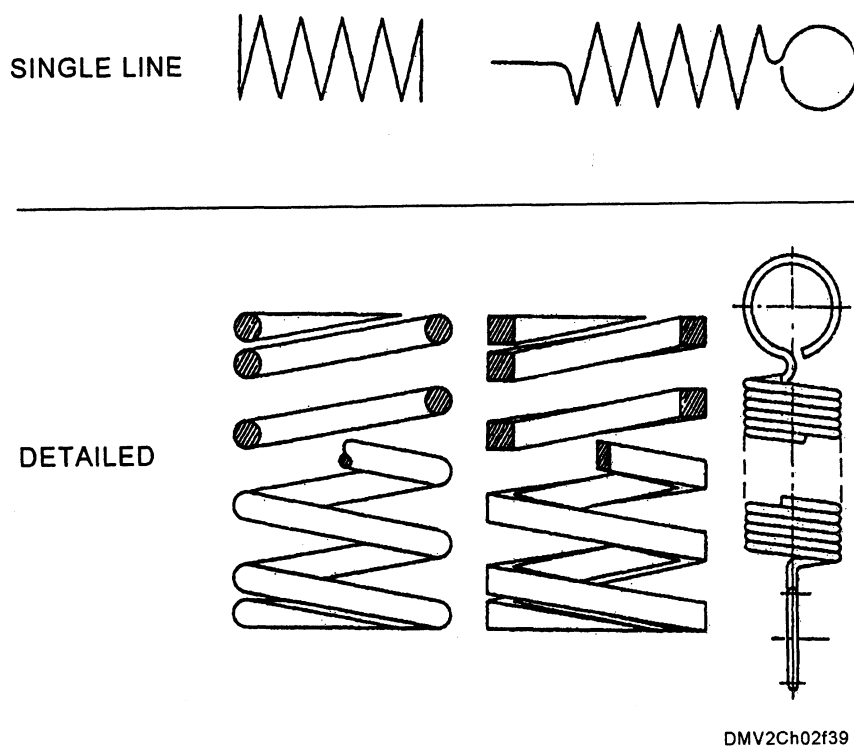


Figure 4-39.—Single-line and detailed representations of helical springs.

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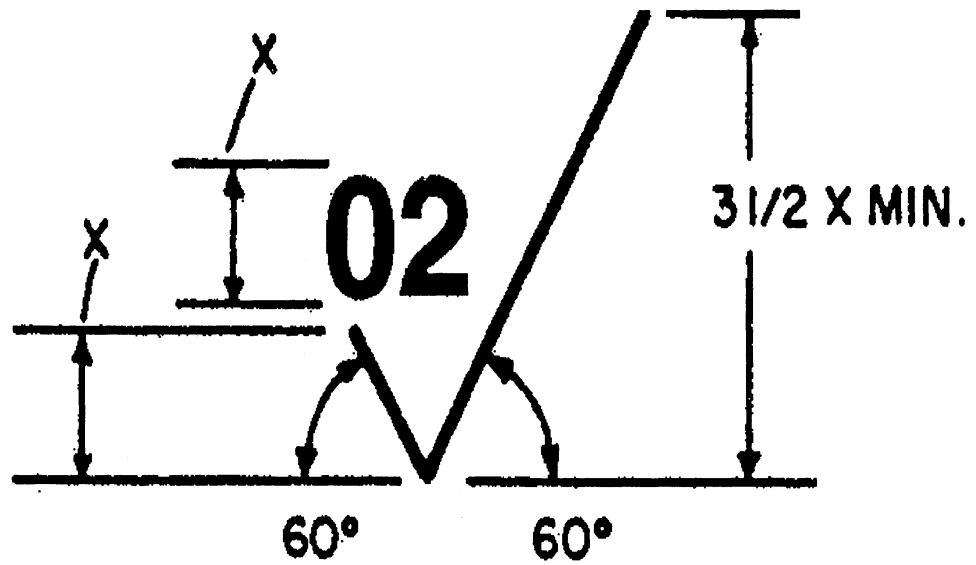
Machine Drawings, Continued

General terms (Continued)

FINISH MARKS: *Finish marks* indicate the amount of acceptable surface abrasion in a finish. The purpose of the part determines what surfaces require finishes while others do not.

Indicate surface finishes by drawing a modified check mark and placing the degree of finish in the angle of the check mark.

Figure 4-40 shows the proportions for a basic finish mark.



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Figure 4-40.—Proportions for a basic finish mark.

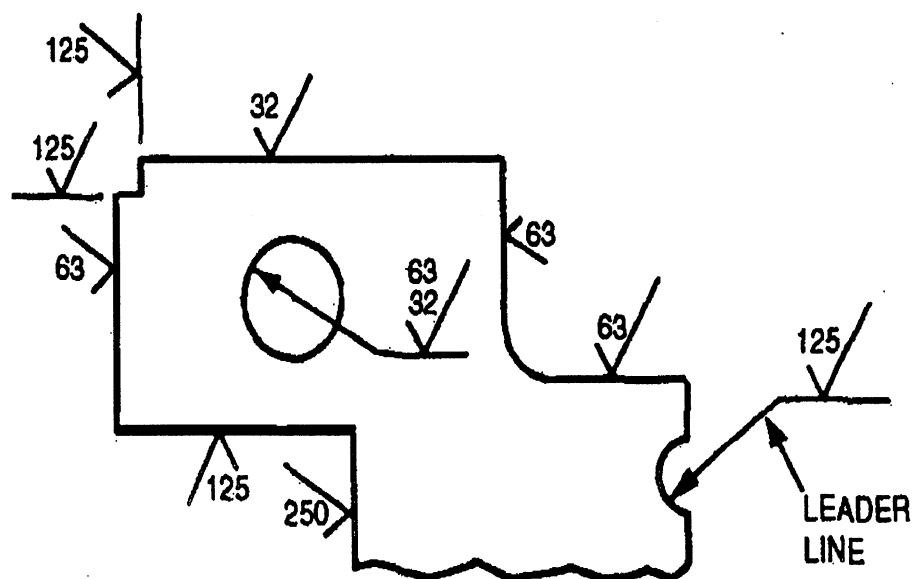
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Machine Drawings, Continued

General terms (Continued)

When possible, draw the finish mark touching the surface to which it refers. In a limited space, draw the symbol on an extension line on that surface or on the tail of a leader line with an arrowhead touching the surface. When a part requires an all over finish, notate on the drawing “FINISH ALL OVER (degree).” When all but a few surfaces are similarly finish, place the finish marks at the appropriate locations and notate on the drawing “FINISH ALL OVER EXCEPT AS NOTED.”

Figure 4-41 shows how to place finish marks.



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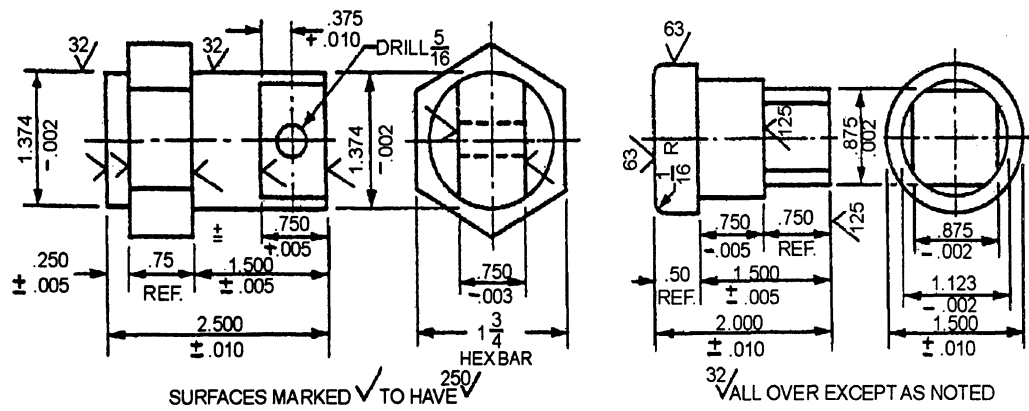
Figure 4-41.—Placing finish marks.

Continued on next page

Machine Drawings, Continued

General terms
(Continued)

Figure 4-42 illustrates typical examples of symbol use.



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Figure 4-42.—Typical examples of symbol use.

Plumbing/Piping Drawings

Introduction

Almost every conceivable fluid is handled in pipes during its production, processing, transportation, and use. Piping is also used as a structural element in columns and handrails. For these reasons, DMs should become familiar with plumbing and piping drawings and the plumbing and piping symbols used to show the size and location of pipes, fittings, and valves. In this section little differentiation is made between plumbing and piping drawings.

Methods of projection

The two types of projection used in plumbing and piping diagrams are orthographic and isometric (pictorial).

ORTHOGRAPHIC PLUMBING OR PIPE DRAWINGS: Orthographic pipe drawings show single pipes either straight or bent in one plane only. Orthographic pipe drawings may be single-line drawings where you draw the center line of the pipe as a thick line and add valves and fittings, or double-line drawings where you draw each valve and fitting. Use the single-line method when speed is essential. Double-line drawings are generally used in applications, such as catalogs, where visual appearance is more important than drawing time. Orthographic pipe drawings are sometimes used on more complicated piping systems.

Figure 4-43 shows an example of a single- and a double-line orthographic piping drawing.

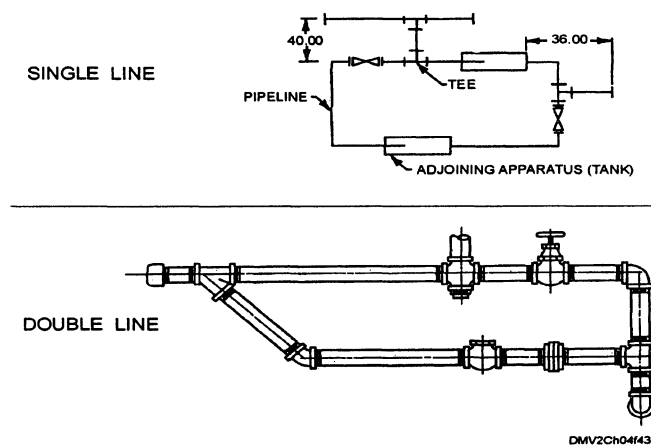


Figure 4-43.—Orthographic pipe drawings.

Continued on next page

Plumbing/Piping Drawings, Continued

Methods of projection (Continued)

ISOMETRIC (PICTORIAL) PLUMBING OR PIPE DRAWINGS: Use isometric pipe drawings for all pipes bent in more than one plane. You may use either the single-line or double-line method. The finished drawings are easier to understand in pictorial format than as orthographic line drawings.

Figure 4-44 is an example of a single-line isometric pipe drawing.

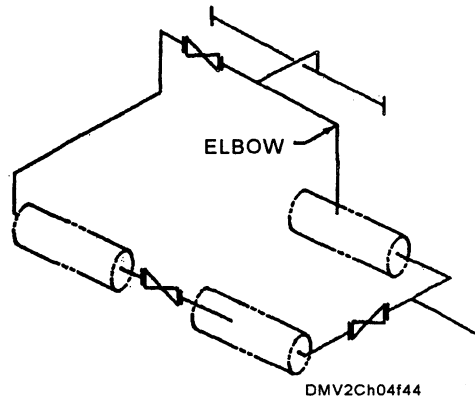


Figure 4-44.—A single-line isometric pipe drawing.

Figure 4-45 is an example of a double-line isometric pipe drawing.

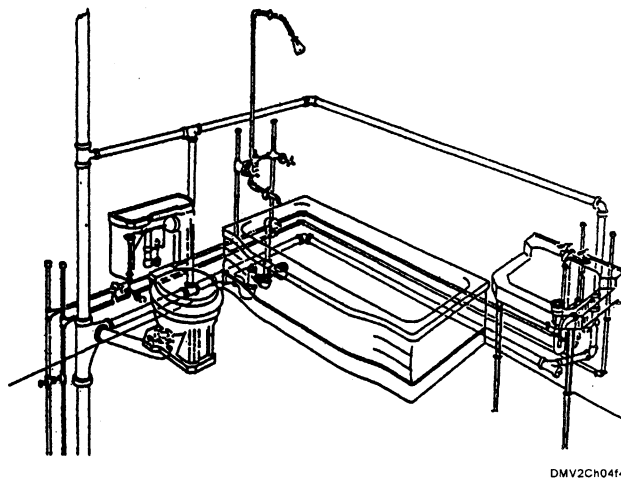


Figure 4-45.—A double-line isometric pipe drawing.

Continued on next page

Plumbing/Piping Drawings, Continued

Crossing pipes

To show pipes that cross each other without connection, draw lines without interruption. When it is important to show that one pipe passes behind another, break or interrupt the line representing the pipe fartherest from the viewer.

Figure 4-46 shows how to cross pipes.

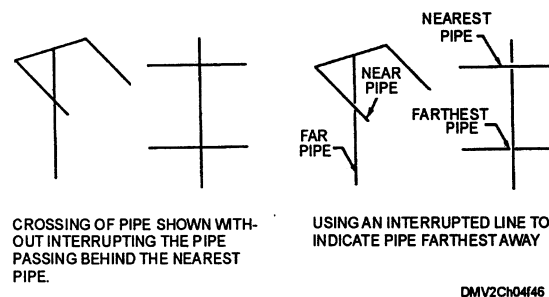


Figure 4-46.—Crossing pipes.

Connecting pipes

Show permanent connection of pipes, whether made by welding or other processes such as gluing or soldering, as a heavy dot with a general note or specification describing the type of connection. Show detachable connections between pipes as a thick single line and a general notation. The bill of material lists this type of connection as flanges, unions, or couplings and whether the fittings are flanged or threaded.

Figure 4-47 shows how to represent permanent and detachable connections.

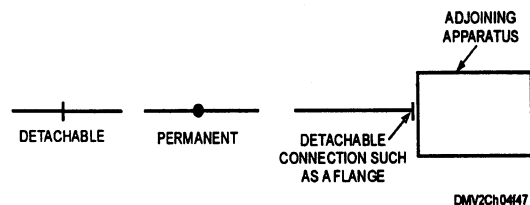


Figure 4-47.—Permanent and detachable connections.

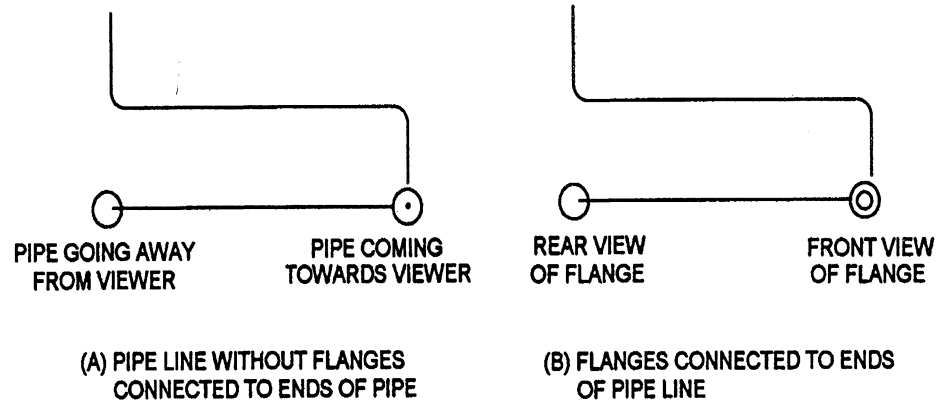
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Plumbing/Piping Drawings, Continued

Fittings

Sometimes standard symbols for fittings like tees, elbows, crossings, and so forth, are not shown on drawings. Use the circular symbol for a tee or elbow when it is necessary to show piping coming toward or moving away from the viewer.

Figure 4-48 illustrates how to draw fitting coming toward or moving away from the viewer.



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Figure 4-48.—Indicating the ends of pipe fittings.

Continued on next page

Plumbing/Pipe Drawings, Continued

Reading fittings Each opening on a fitting is identified with a letter. On crosses and elbows, you always read the largest opening first and then follow the alphabetical order in figure 4-49. On tees, 45-degree Y-bends or laterals, and double-branch elbows, read the largest opening first, the opposite opening next, and the outlet last.

Figure 4-49 show the order in which you read fittings.

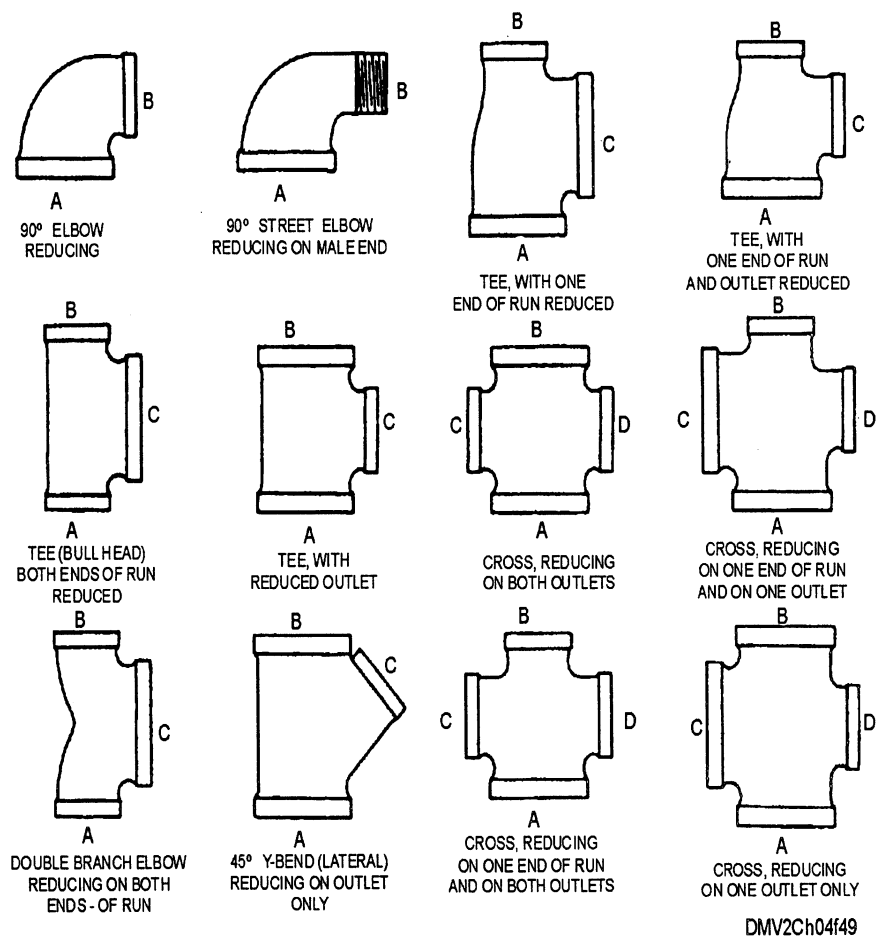


Figure 4-49.—Plumbing fittings

Continued on next page

Plumbing/Piping Drawings, Continued

Symbols and markings

MIL-STD-17B, part I, lists mechanical symbols used on piping prints other than those used for aeronautical, aerospacecraft, and spacecraft (listed in part II). When an item is not covered in the standards, the responsible or originating activity designs a suitable symbol and explains it in a note. When more than one piping system of the same kind appears on a print, use letters added to the symbols to differentiate between the systems.

Figure 4-50 is a list of common pipe line symbols.

NOTE: WHERE LINE SYMBOLS ON ANY ONE DRAWING ARE DUPLICATES OF ANOTHER SERVICE LETTER SYMBOLS MAY BE ADDED.	
DIRECTION OF FLOW	—————→—————←—————
AIR CONDITIONING	
BRINE RETURN	— — — — — BR — — — — —
BRINE SUPPLY	————— B —————
CIRCULATING CHILLED OR HOT-WATER FLOW	————— CH —————
CIRCULATING CHILLED OR HOT-WATER RETURN	— — — — — CHR — — — — —
CONDENSER WATER FLOW	————— C —————
CONDENSER WATER RETURN	— — — — — CR — — — — —
DRAIN	————— D —————
HUMIDIFICATION LINE	— - - - - H - - - - -
MAKE-UP WATER	— - - - - — - - - -
REFRIGERANT DISCHARGE	————— RD —————
REFRIGERANT LIQUID	————— RL —————
REFRIGERANT SUCTION	— — — — — RS — — — — —
HEATING	
AIR-RELIEF LINE	— — — — — — — — — —
BOILER BLOW OFF	————— —————
COMPRESSED AIR	————— A —————
CONDENSATE OR VACUUM PUMP DISCHARGE	— O — — O — — O — —
FEEDWATER PUMP DISCHARGE	— OO — — OO — — OO — —
FUEL-OIL FLOW	————— FOF —————
FUEL-OIL RETURN	— — — — — FOR — — — — —
FUEL-OIL TANK VENT	— — — — — FOV — — — — —
HIGH-PRESSURE RETURN	— // — — // — — // — —
HIGH-PRESSURE STEAM	— // — — // — — // — —
HOT-WATER HEATING RETURN	— — — — — — — — — —
HOT-WATER HEATING SUPPLY	————— —————

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Figure 4-50.—Common pipe line symbols.

Continued on next page

Plumbing/Piping Drawings, Continued

Symbols and markings (Continued)

Figure 4-51 is a list of common piping symbols

PIPE FITTINGS, TYPES OF CONNECTIONS					
SCREWED ENDS		CAP		STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 3 PORT	
FLANGED ENDS		COUPLING		STOP COCK, PLUG OR CYLINDER VALVE, 4 WAY, 4 PORT	
BELL-AND-SPIGOT ENDS		PLUG			
WELDED AND BRAZED ENDS		REDUCER, CONCENTRIC			
SOLDERED ENDS		UNION, FLANGED			
		UNION, SCREWED			
ELBOWS		EXPANSION JOINT, BELLLOWS		RELIEF, REGULATING, AND SAFETY VALVES	
FITTING	SYMBOL	EXPANSION JOINT, SLIDING		VALVE	SYMBOL
ELBOW, 90 DEGREES		VALVES, TYPES OF CONNECTIONS.		GENERAL SYMBOL	
ELBOW, 45 DEGREES		SCREWED ENDS		ANGLE, RELIEF	
ELBOW, OTHER THAN 90 OR 45 DEGREES, SPECIFY ANGLE		FLANGED ENDS		BACK PRESSURE	
ELBOW, LONG RADIUS		BELL-AND-SPIGOT ENDS		GLOBE, RELIEF	
ELBOW, REDUCING		WELDED AND BRAZED ENDS			
ELBOW, SIDE OUTLET, OUTLET DOWN		SOLDERED ENDS			
ELBOW, SIDE OUTLET, OUTLET UP		STOP VALVES		GLOBE, RELIEF ADJUSTABLE, OR SPRING LOADED REDUCING	
ELBOW, TURNED DOWN		VALVE	SYMBOL	PRESSURE REDUCING OR PRESSURE REGULATING, INCREASED ACTUATING PRESSURE CLOSES VALVE	
ELBOW, TURNED UP		GENERAL SYMBOL		PRESSURE REDUCING OR PRESSURE REGULATING, INCREASED ACTUATING PRESSURE OPENS VALVE	
ELBOW, UNION		ANGLE		PRESSURE REGULATING, WEIGHT-LOADED	
TEES		GATE		SAFETY, BOILER	
FITTING	SYMBOL	GATE, ANGLE			
TEE		GLOBE		CHECK VALVES	
TEE, DOUBLE SWEEP		GLOBE, AIR OPERATED, SPRING CLOSING		VALVE	SYMBOL
TEE, OUTLET DOWN		GLOBE, DECK OPERATED		GENERAL SYMBOL	
TEE, OUTLET UP		GLOBE, HYDRAULICALLY OPERATED		CHECK, LIFT	
TEE, SINGLE SWEEP, OR PLAIN T-Y		STOP COCK, PLUG OR CYLINDER VALVE, 2 WAY		CHECK, SWING	
OTHER PIPE FITTINGS		STOP COCK, PLUG OR CYLINDER VALVE, 3 WAY, 2 PORT		GLOBE, STOP CHECK	
FITTING	SYMBOL				
BUSHING					

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Figure 4-51.—Common piping symbols.

Continued on next page

Plumbing/Piping Drawings, Continued

Symbols and markings (Continued)

Figure 4-51 is a continuation of the list of common piping symbols.

OTHER VALVES		BUCKET TRAP		VACUUM-PRESSURE	
VALVE	SYMBOL	FLOAT TRAP	SYMBOL	THERMOMETER	SYMBOL
AUTOMATIC, OPERATED BY GOVERNOR		P TRAP		THERMOMETER, DISTANT READING, BARE BULB TYPE	
DIAPHRAGM		RUNNING TRAP		THERMOMETER, DISTANT READING, SEPARATE SOCKET TYPE	
FAUCET		TRAP		AIR CHAMBER	
FLOAT OPERATED		POWER AND HEATING PLANT EQUIPMENT		BULKHEAD JOINT, EXPANSION	
LOCK AND SHIELD		UNIT	SYMBOL	BULKHEAD JOINT, FIXED	
MANIFOLD		AIR EJECTOR		METER, DISPLACEMENT TYPE (OTHER THAN ELECTRICAL)	
PUMP GOVERNOR		BLOWER		ORIFICE	
SOLENOID CONTROL		BLOWER, SOOT		SEA CHEST, DISCHARGE	
THERMOSTATICALLY CONTROLLED		BOILER, STEAM GENERATOR (WITH ECONOMIZER)		SEA CHEST, SUCTION	
STRAINERS		ENGINE, STEAM		REFRIGERATION EQUIPMENT	
TYPE	SYMBOL	EVAPORATOR, SINGLE EFFECT		UNIT	SYMBOL
BOX STRAINER		PUMP, RECIPROCATING		COIL, PIPE	
DUPLEX OIL FILTER		PUMP, ROTARY AND SCREW		COMPRESSOR (ALL TYPES)	
DUPLEX STRAINER		TURBINE, STEAM		CONDENSER, EVAPORATIVE	
STRAINER		GAGES, THERMOMETERS, AND MISCELLANEOUS		CONDENSING UNIT, AIR COOLED	
Y STRAINER		TYPE	SYMBOL	CONDENSING UNIT, WATER COOLED	
TRAPS		LIQUID LEVEL		COOLER, BRINE	
TYPE	SYMBOL	PRESSURE		SWITCH, CUT-OUT, HIGH PRESSURE	
AIR ELIMINATOR		VACUUM		SWITCH, CUT-OUT, LOW PRESSURE	
BOILER RETURN TRAP				VALVE, EVAPORATOR PRESSURE REGULATING SNAP-ACTION VALVE	
				VALVE, EXPANSION, AUTOMATIC	
				VALVE, EXPANSION, MANUALLY OPERATED	
				VALVE, EXPANSION, THERMOSTATIC	

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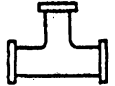

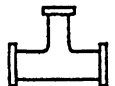
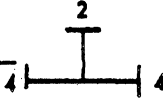
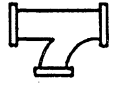
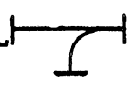


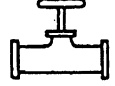
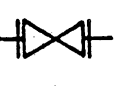




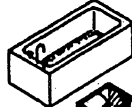



Figure 4-51.—Common piping symbols (continued).

Continued on next page

Plumbing/Piping Drawings, Continued

Symbols and markings (Continued)

Figure 4-52 is a list of common plumbing symbols.

	ILLUSTRATED	SYMBOLS (THREADED)
90° ELBOWS		
STRAIGHT TEE		
REDUCING TEE		
SANITARY TEE		
P-TRAP		
GATE VALVE		
SHOWER HEAD		
LAVATORY (SINKS)		
BATH TUBS		
SHOWER STALL		

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Figure 4-52.—Common plumbing symbols.

Continued on next page

Plumbing/Piping Drawings, Continued

Color codes

MIL-STD-101C establishes the color code used to identify piping carrying hazardous fluids. It applies to all piping installations in naval industrial plants and shore stations that use color coding. All valve wheels must be color coded. Color coding on pipes is optional.

This list outlines common color codes for fluid under MIL-STD-101C.

Part	Function
Yellow	Flammable materials
Brown	Toxic and poisonous materials
Blue	Anesthetics and harmful materials
Green	Oxidizing materials
Grey	Physically dangerous materials
Red	Fire protection materials

Fluid lines on aircraft are marked according to MIL-STD-1247C, *Markings, Functions, and Designations of Hoses, Piping, and Tube Lines for Aircraft, Missiles, and Space Systems*. Aircraft fluid lines are also marked with an arrow to show direction of flow and a hazard marking. The four general classes of hazards are FLAM for flammable or combustible materials, TOXIC for material extremely hazardous to life or health, AAHM for anesthetics, vaporous and nonvaporous that present dangers to life and health, and PHDAN for materials that by themselves are not dangerous but present the danger of asphyxiation. PHDAN material are often pressurized or temperature sensitive.

Continued on next page

Plumbing/Piping Drawings, Continued

Color codes (Continued)

Figure 4-53 lists color codes and symbols for aircraft fluid lines.

FUNCTION	COLOR	SYMBOL
Fuel	Red	◆
Rocket Oxidizer	Green, Gray	☾
Rocket Fuel	Red, Gray	◆☾
Water Injection	Red, Gray, Red	▼
Lubrication	Yellow	⋮
Hydraulic	Blue, Yellow	●
Solvent	Blue, Brown	≡
Pneumatic	Orange, Blue	X
Instrument air	Orange, Gray	∞
Coolant	Blue	~
Breathing Oxygen	Green	■
Air Conditioning	Brown, Gray	⋈
Monopropellant	Yellow, Orange	T
Fire Protection	Brown	◆
Deicing	Gray	▲
Rocket Catalyst	Yellow, Green	▮
Compressed gas	Orange	↘
Electrical Conduit	Brown, Orange	⚡
Inerting	Orange, Green	++

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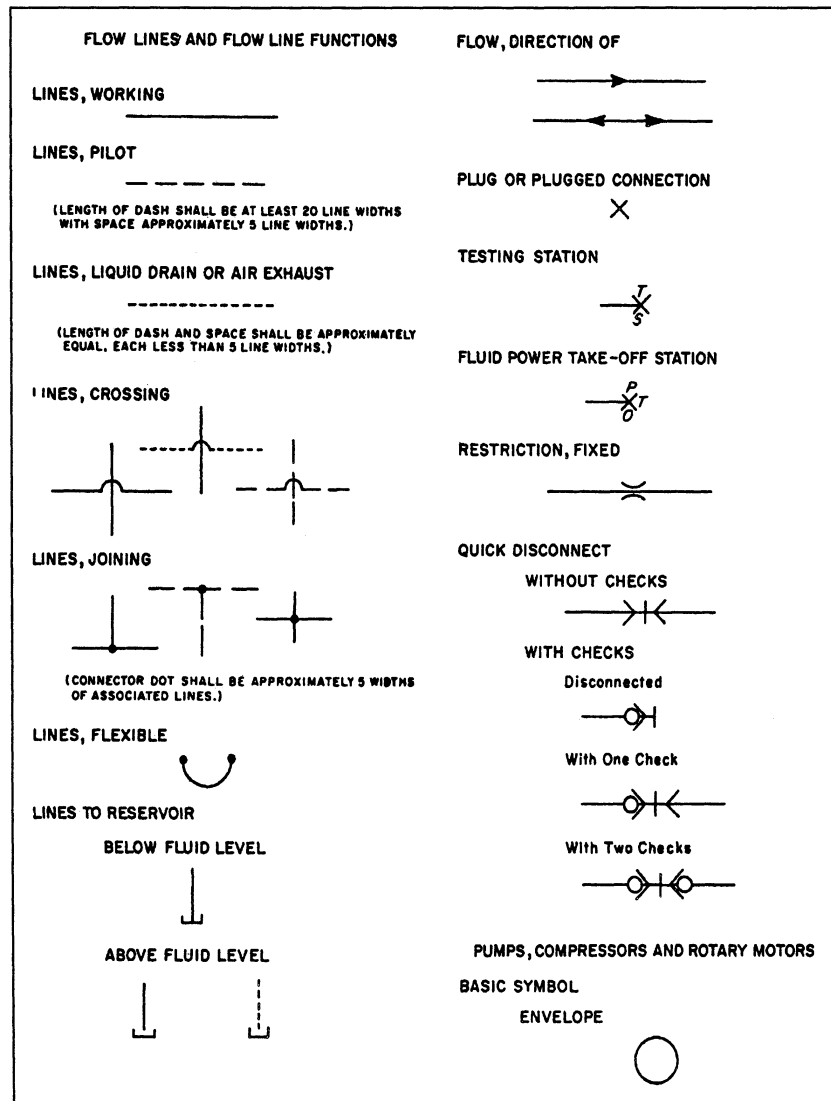
Figure 4-53.—Aircraft fluid line color codes and symbols.

Continued on next page

Plumbing/Piping Drawings, Continued

Fluid power symbols

Figure 4-54 is a list of common fluid power symbols.



DMV2Ch04f55

Figure 4-54.—Fluid power symbols.

Continued on next page

Plumbing/Piping Drawings, Continued

Shipboard piping prints

Standard piping symbols appear on shipboard piping prints with a symbol list. Sometimes symbol lists are left off the print; therefore, you must be familiar with standard symbols. Many operation and maintenance manuals do not use standard symbols because these systems are drawn in detail or pictorially.

Hydraulic prints

Hydraulic systems are on aircraft and on board ships activating weapons systems, navigational equipment, and remote controls of numerous mechanical devices. Shore stations use hydraulically driven maintenance and repair shop equipment. Hydraulic systems are also used in construction, automotive, and weight-handling equipment. In general hydraulic lines are designated as *supply lines*, which carry fluids from a reservoir to pumps, *pressure lines* that carry only pressure, *operating lines* that alternately carry pressure to and return fluids from an actuating unit, *return lines* return fluids to the reservoir, and *vent lines* that carry excess fluids overboard or into another receptacle. To distinguish one hydraulic line from another, the DM designates each line according to its function within the system. MIL-STD-17B, part II, lists symbols used on hydraulic systems. On drawings of hydraulic systems, basic symbols often show a cut-away section to clarify operation.

Figure 4-55 shows basic types of hydraulic symbols.

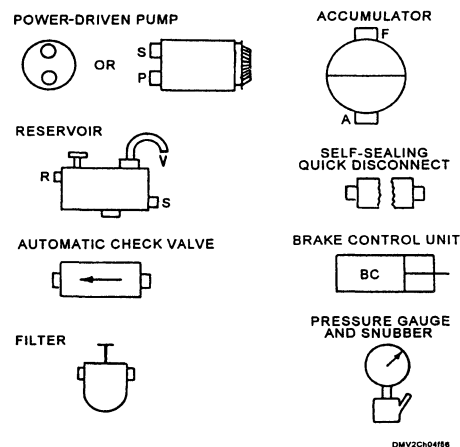


Figure 4-55.—Basic types of hydraulic symbols.

Summary

Review

This chapter introduces you to various types of technical drawings. Beginning with a brief description of technical sketching and technical drawing followed by architectural/structural drawings, electrical/electronic drawings, machine drawings, and, finally, plumbing/piping drawings. Each section has a vocabulary and symbology that is unique. There are superficial directions on how the DM should approach each type of technical drawing and the significance of different drawings within each type. The chapter ends with hydraulic systems.

Comments

This chapter is not meant to be your sole reference to technical drawings. Before plunging in to draw, revise, or interpret each type of technical drawing, pull the appropriate references and study the symbols. As an Illustrator Draftsman, you may or may not have an opportunity to work on each of these types of technical drawings. You should, however, be familiar with the various types of technical drawings and know where to look for guidance in the event you are required to draw, revise, or interpret one. Opportunity abounds for well-versed draftsmen in the civilian community especially if you can compliment your knowledge and abilities with computer savvy.
